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A Study of Indicator Minerals for Kimberlite, Base Metals and Gold: Kasabonika, Ontario

by

D. Stone

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Contents

Abstract xi

Introduction 1

Regional Geologic Setting 1

Local Geology and Bedrock Sampling 3

Quaternary Geology 5

Rock Sample Processing and Quaternary Sampling 5

Heavy Mineral Recovery and Analysis 5

Results 10

- Rock Analyses 10
- Analysis of Pebble Lithology 16
- Gold 16
- Metamorphosed or Magmatic Massive Sulphide Indicator Minerals (MMSIMs®) 17
- Kimberlite Indicator Minerals 24
  - Chrome Diopside 24
  - Chromite 24
  - Ilmenite 25
  - Garnet 25

Summary 25

Acknowledgements 29

References 29

Metric Conversion Table 32

FIGURES

1. Regional geologic setting of the Kasabonika area 2
2. Local geology of the Kasabonika area showing sample sites 4
3. (a) Classification of sample 01DS08 using the cation diagram of Jensen (1976). (b) Trace element pattern of sample 01DS08 normalized to primitive mantle using values of Sun and McDonough (1989) 15
4. Compositional fields of zincian spinels from marbles (1), aluminous metasediments (2), pegmatites (3), and metamorphosed massive sulphides (4) from Dunlop (2000) with superimposed data from the Kasabonika area 19
5. (a) Classification of Kasabonika pyroxene grains on the wollastonite (WO)-enstatite (EN)-ferrosillite (FS) diagram of Morimoto (1989). (b) Compositions of Kasabonika clinopyroxene grains on the Cr/Al/Na diagram of Morris et al. (in press) 21
6. Scanning electron microscope image of selected chromite grains from sample 01DST14 22

7. Compositions of chromite grains from the Kasabonika area 23
8. Ilmenite compositions from the Kasabonika area shown in terms of ilmenite-hematite-geikilite end-members 26
9. Cr_2O_3-CaO systematics of Kasabonika pyrope garnet 26
10. Distribution of kimberlite indicators, Kasabonika Lake area 28

TABLES*

1. Sample locations, descriptions and type of analyses 6
2. Analyses of rock samples 7
3. Distribution of pebble lithologies 8
4. Processing data 9
5. Summary of gold grain data 9
6. Metamorphosed or magmatic sulphide indicator minerals 11
7. Kimberlite indicator mineral counts 12
8. Picking remarks 12
9. Mineral chemistry of indicator grains 13
10. Comparison of heavy minerals of the Kasabonika area with indicator minerals associated with base metal mineralization, metamorphic rocks and mafic/ultramafic intrusions 18

*Tables are also available in digital format as Miscellaneous Report–Data 103 (MRD 103), available separately from this report.

Abstract

A reconnaissance sampling survey of bedrock and surficial materials (beach pebbles, beach sand, and till) in the Kasabonika area of Ontario was done by staff of the Ontario Geological Survey and prospectors of the Kasabonika First Nation in August 2001. Rock samples were analyzed for a complete range of elements or selective base metals and precious metals. Heavy mineral concentrates were separated from the samples of sand and till and picked for indicator minerals of gold, base metal mineralization and kimberlite. The sampling and analyses are intended to provide an initial assessment of geology and mineral potential in parts of the Kasabonika area and to develop prospecting methods in extensively glaciated terrain.

Amphibole gneiss at the Anderson showing (25 km northeast of Kasabonika) is interpreted, on the basis of major and trace element characteristics, to represent a metamorphosed basaltic lava flow. The basalt has primitive-mantle normalized trace element characteristics that are similar to mafic volcanic sequences of the Oxford-Stull terrane in the Stull Lake area of the northern Superior Province. Gabbro intrusions at Kasabonika and 5 km northwest of Kasabonika are locally mineralized with sulphide minerals. Assays of sulphide-mineral-bearing grab samples from these intrusions returned negligible values of Cu, Ni and platinum group elements.

Pebbles on beaches of Kasabonika Lake contain an assortment of Archean felsic plutonic, volcanic and sedimentary clasts that are representative of bedrock in the area. Rare clasts of mylonite and muscovite granite allude to faults and peraluminous granite bodies with potential for rare metal mineralization in the area. Up to 12% of pebbles are Paleozoic material that have been transported in excess of 60 km southwesterly from the Hudson Bay lowlands. Analysis of pebble fractions appears to represent a useful guide for bedrock mapping and prospecting in extensively glaciated areas such as Kasabonika.

Till at the Anderson showing and beach sand at the shoreline of Kasabonika Lake contain background numbers of gold grains and no gold grains, respectively. The lack of gold grains in beach material probably occurs because detrital gold grains are fine, silt-sized particles and have been washed out of the coarse sand. Till represents a preferred medium for gold studies. Till sampling surveys need to be undertaken to assess the gold potential broadly in the Kasabonika area.

Sand on beaches of Kasabonika Lake contain an assortment of dense minerals including chalcopyrite, pyrite, gahnite, Magnesium-spinel, clinopyroxene, orthopyroxene, rutile, kyanite, sillimanite, staurolite, spessartine and chromite. These minerals can have originated from a variety of sources including non-mineralized metamorphic rocks or mafic/ultramafic intrusions, volcanosedimentary massive sulphide deposits, mineralized mafic/ultramafic intrusions and peraluminous granite pegmatite. The compositions of clinopyroxene and chromite suggest that some of these grains have possibly been derived from mafic/ultramafic intrusions although it is unclear whether or not the intrusions are mineralized. Gahnite grains in the beach sand are compositionally similar to gahnite derived from pegmatite and suggest that pegmatite with possible associated rare metal mineralization (Li, Rb, Cs, Be, Nb, Ta and Ga) occurs locally.

Kimberlite indicators including Chrome-diopside, chromite, ilmenite and pyrope garnet are identified in heavy mineral concentrates of beach sand. Although these dense minerals show evidence of concentration by placer effects in some samples, the average number of kimberlite indicators per sample is high (2:1) at Kasabonika. This suggests that further exploration for kimberlite is warranted in the Kasabonika area.

A Study of Indicator Minerals for Kimberlite, Base Metals and Gold: Kasabonika, Ontario

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Introduction

In August 2001, a suite of soil and rock samples were collected in the area of Kasabonika, Ontario (Figure 1). The sampling was done jointly by staff of the Ontario Geological Survey and prospectors of the Kasabonika Lake First Nation. The soil samples were processed for indicator grains of gold, metamorphosed or magmatic sulphides and kimberlite. Two rock samples showing visible sulphide mineralization were assayed for base metals and precious metals and one sample of a metamorphosed mafic gneiss of probable volcanic origin was analysed for a full range of major and trace elements.

The sampling and analyses provides a preliminary assessment of the potential for gold, base-metal and diamond mineralization in two local parts of the Kasabonika area. The assessment is done partly by comparing the number of indicator grains of gold, metamorphosed or magmatic sulphides and kimberlite in the soil samples with results from other sampling surveys in far northern Ontario. The mineralized rocks were assayed to determine if they contain significant concentrations of economically valuable metals including copper, nickel, gold, palladium and platinum. The analysis of the mafic gneiss provides a means of confirming the volcanic origin of the rock as well as facilitating correlation between the gneissic belt at Kasabonika and regional metavolcanic suites.

Regional Geologic Setting

The Kasabonika area is situated in the northeastern Superior Province of Ontario and is underlain by curvilinear Archean greenstone belts interspersed with relatively larger domains of felsic plutonic rocks. The Kasabonika area (*see* Figure 1) comprises part of the volcano-plutonic Sachigo Subprovince of Card and Ciesielski (1986). The Sachigo Subprovince is composed of a series of mainly fault-bounded crustal blocks including the North Caribou, and Oxford-Stull terranes and the Northern Superior superterrane (*see* Figure 1). The North Caribou terrane contains greenstone and plutonic sequences of 2.9 to 3.0 Ga age and is thought to represent remnants of an early microcontinent (Thurston, Osmani and Stone 1991). Various other terranes north of the North Caribou terrane represent crustal material developed on or accreted to the margin of the North Caribou terrane from 2.9 to 2.7 Ga (e.g. Skulski et al. 2000). Within this regional context, Kasabonika is thought to lie within the Oxford -Stull terrane.

In the area of the Manitoba-Ontario border, the Oxford-Stull terrane comprises two major groups of supracrustal rocks and several plutonic suites. The supracrustal rocks include basalts correlated with the Hayes River Group (2.83 Ga), calc-alkaline to shoshonitic volcanic rocks dated at 2.73 to 2.72 Ga (volcanic subgroup of the Oxford Lake Group) and overlying conglomerate and sandstone (ca 2.71 Ga) representing the sedimentary subgroup of the Oxford Lake Group (Skulski et al. 2000; Stone et al. in press). The basalts are variably LREE and Th-depleted or -enriched and may represent lavas erupted on an ocean floor and in a volcanic arc developed on a continental margin, respectively (Skulski et al. 2000). The calc-alkaline to alkaline volcanics and sediments of the Oxford Lake Group are interpreted as volcanic arc and continental pull-apart deposits, respectively developed in response to accretion and underthrusting of the Northern Superior superterrane at 2.73 to 2.71 Ga. The plutonic rocks range in age from 2.82 to 2.71 Ga and include the early biotite tonalite suite (2.82 Ga) and late hornblende tonalite, biotite granite and monzodioritic sanukitoid suites (2.72 to 2.71 Ga).

The Oxford-Stull terrane is bounded in the south and in the north by the Stull-Wunnummin and Kenyon faults, respectively. These faults are complexly curved and splayed structures composed of broad zones of mylonite that strike east-southeasterly (*see* Figure 1). The faults are defined by mapping in the

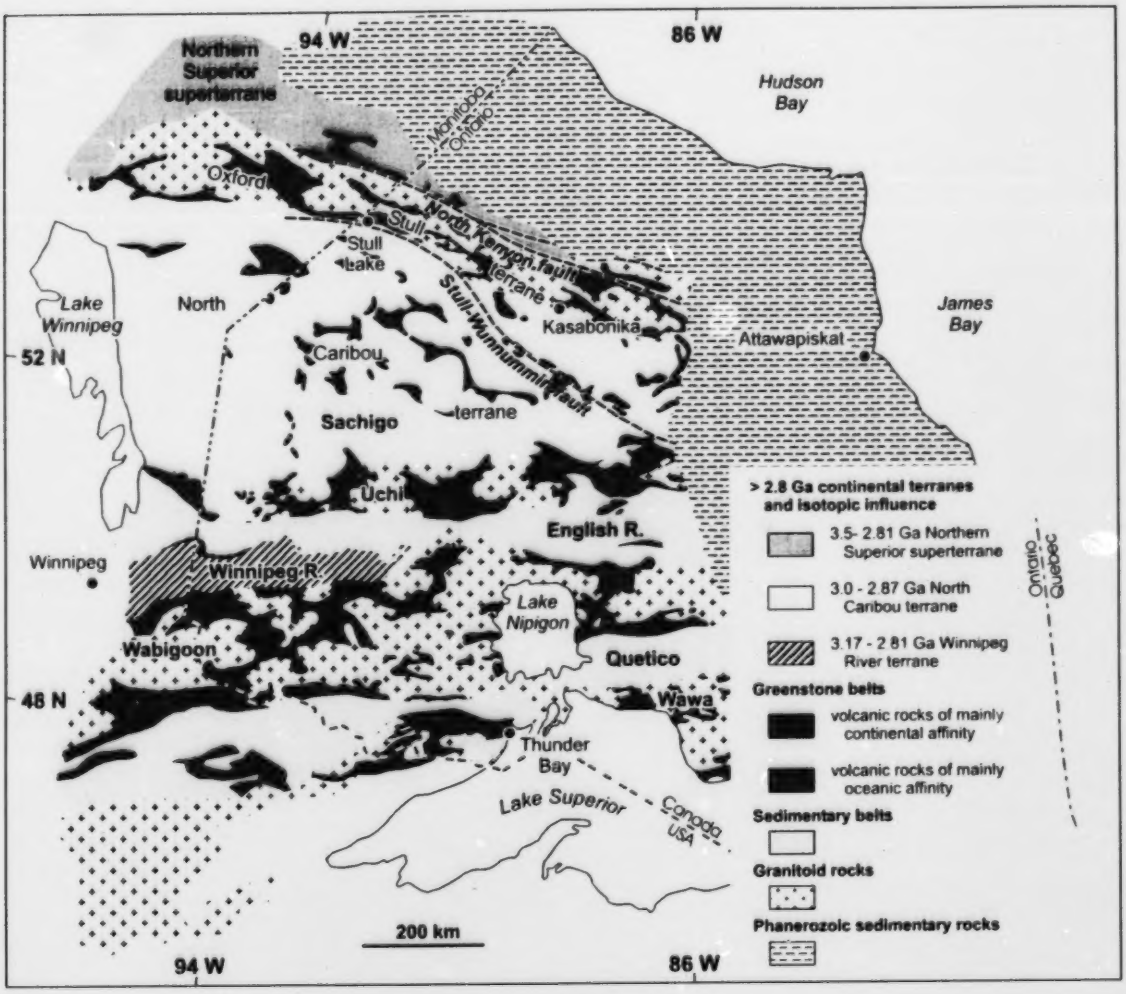

Figure 1. Regional geologic setting of the Kasabonika area.

area of the Manitoba-Ontario border (Stone et al. in press), but the positions of the faults are less certain to the east and are inferred from aeromagnetic maps. The Stull-Wunnummin fault is interpreted to occur 80 km south of Kasabonika and splays of the Kenyon fault occur from 30 to 80 km north of Kasabonika (Ontario Geological Survey 1991).

The Oxford-Stull terrane is juxtaposed across the Kenyon fault with gneissic and plutonic rocks and small greenstone slivers comprising the Northern Superior superterrane. Recent geochronologic work summarized by Skulski et al. (2000) and Stone et al. (in press) has identified zircon grains as old as 3.15 and 3.57 Ga in the gneisses. The Northern Superior superterrane is interpreted as an old cratonic mass that was extensively reworked by felsic plutonism at 2.84 Ga and subsequently at 2.72 to 2.71 Ga. The latter plutonism occurred during and after docking of this terrane with the Oxford-Stull terrane.

Although identified in the area of the Manitoba-Ontario border, the eastern extent of the Northern Superior superterrane is not well known due to lack of bedrock mapping and geochronologic work. In the area north of Kasabonika, it is unclear as to which, if any, of the splays of the Kenyon fault represent the south margin of the Northern Superior superterrane.

Local Geology and Bedrock Sampling

Kasabonika is situated at the western end of the Kasabonika Lake-Ekwan River greenstone belt of Thurston, Sage and Siragusa (1979). This poorly exposed belt of predominantly mafic metavolcanic rocks extends eastward from Kasabonika for a distance of 155 km to the Ekwan River and attains a maximum width of 10 km. In the area of Kasabonika, the Kasabonika Lake-Ekwan River greenstone belt bifurcates into westerly and northwesterly arms (Figure 2). A unit of metasedimentary rocks comprising mainly wacke occurs at the south side of the greenstone belt including the western arm of the greenstone belt, and attains a width of up to 5 km.

The Kasabonika Lake-Ekwan River greenstone belt is surrounded by undifferentiated felsic plutonic and gneissic rock. A body of massive, coarse-grained gabbro up to 5 km long occurs within the felsic country rocks at Kasabonika (Thurston, Sage and Siragusa, 1979; *see* Figure 2). Contact relations between the gabbro and felsic plutonic rocks are unknown.

Three outcrops were sampled and include coarse, massive gabbro and diorite located approximately 3 and 5 km northwest of Kasabonika (at the sites of samples 01DS06 and 01DS07, respectively; *see* Figure 2). These are representative of the gabbro body defined previously by Thurston, Sage and Siragusa (1979) and an unknown intrusive mass within the sedimentary unit of the greenstone belt. Sulphide minerals occur locally as disseminations and thin fracture fillings in rocks at both outcrops.

The third exposure of bedrock comprises a low ridge of outcrop in the northwesterly-trending arm of the greenstone belt about 25 km northeast of Kasabonika (site of sample 01DS08; *see* Figure 2). The ridge of outcrop consists dominantly of strongly foliated, black amphibolite and amphibolite gneiss probably representative of metamorphosed basaltic lava flows. At the southeast end of the ridge of outcrop, amphibolite is cut by foliated, white to pink, muscovite granite. A shear zone and associated quartz vein that is 0.1 to 0.3 m wide cuts the amphibolite and can be traced over a distance of more than 10 m. The quartz vein contains blebs of chalcopyrite and has been trenched and sampled by prospectors.

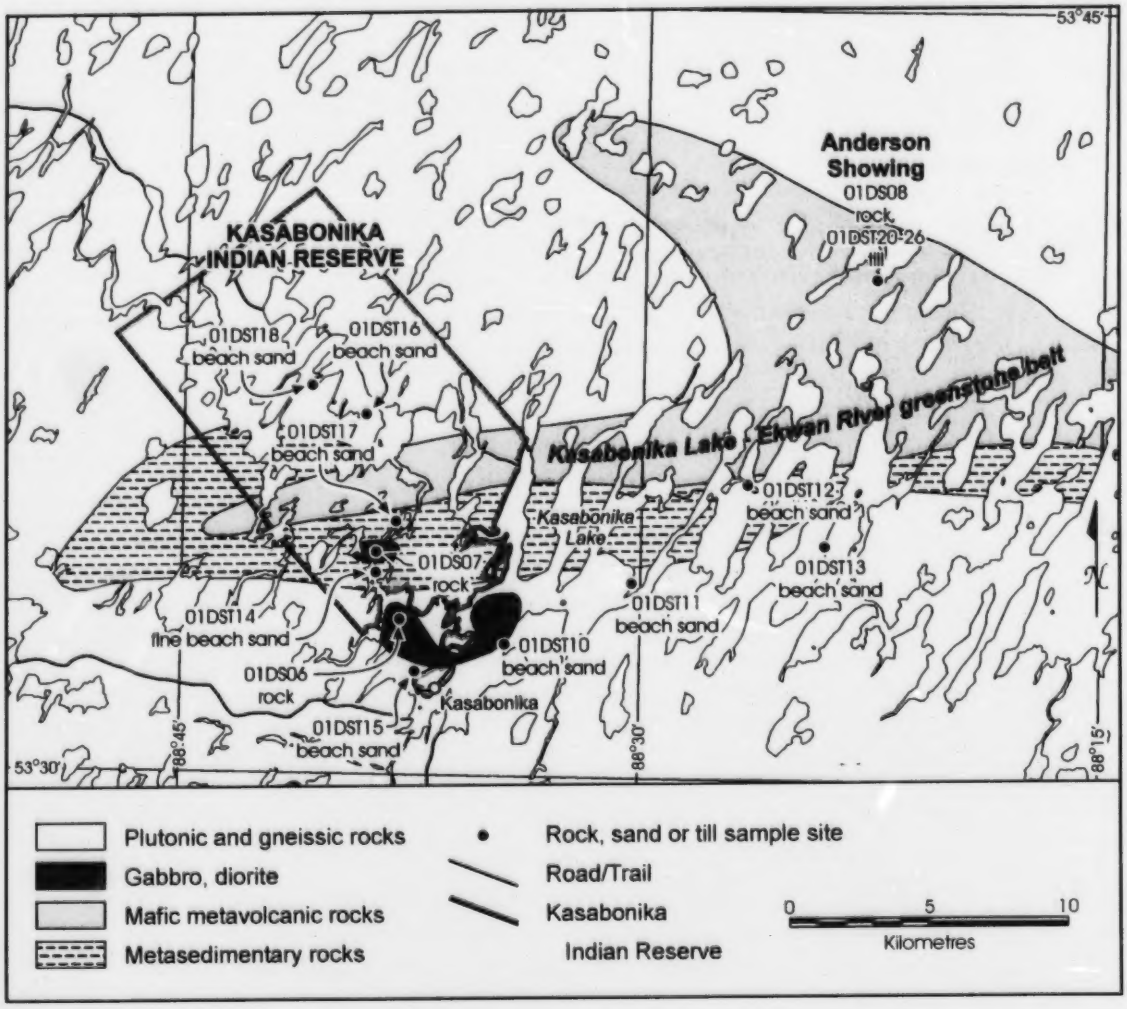

Figure 2. Local geology of the Kasabonika area showing sample sites.

Quaternary Geology

The Quaternary geology, landforms and soil characteristics of the Kasabonika area are strongly influenced by the effects of glaciation including the advance and melt-out of the Laurentide ice sheet (Dyke and Prest 1987; Barnett 1991). Although subdued, terrain of the Kasabonika area is marked by a series of low, southwesterly-oriented ridges and valleys interspersed with elongate lakes. The linear landforms are visible in satellite image maps (Singhroy et al. 2002) and appear to represent a drumlinized till plain. Sand and gravel beaches are developed on the shorelines of lakes that abut drumlins. Organic deposits including peat and muck occur locally in topographic depressions.

At the Anderson showing (*see* Figure 2), thin till blankets bedrock. The till is greyish weathering red and contains a large silt component possibly reflecting incorporation of carbonate rocks of the Hudson Bay lowlands. Glacial striations oriented at 225° are developed on bedrock at the Anderson showing.

Rock Sample Processing and Quaternary Sampling

Samples of fresh rock (01DS06, 01DS07 and 01DS08 of Table 1), typically of 1 to 2 kg, were analyzed at the Geoscience Laboratories, Sudbury. The methods of analyses, detection limits and analytical results are listed in Table 2. Major oxides and volatiles were determined by X-ray fluorescence (WD-XRF) and infrared combustion (IR Spectr.), respectively. Various trace elements and rare earth elements were determined by inductively coupled plasma optical emission spectrometry (ICP-OES) and inductively coupled plasma mass spectrometry (ICP-MS) following the methods outlined by Vander Voet and Riddle (1993).

Approximately 10 kg of beach sand (samples 01DST10 to 01DST18, Table 1) were collected from nine sites on the shorelines of lakes and rivers in the area of Kasabonika (*see* Figure 2). At three localities from which beach sand was collected, 1 to 2 kg samples of the pebble fraction of beach material were also collected (samples 01DST11b, 01DST13b and 01DST15b, Table 1). The pebble fractions were examined and sorted according to pebble lithology (Table 3). Seven samples of till (01DST20 to 01DST26, Table 1), each weighing approximately 10 kg, were extracted from shallow pits in the area of the outcrop ridge at the Anderson Showing, northeast of Kasabonika (*see* Figure 2). The till sample sites are spaced 50 to 100 m apart within surficial materials onlapping the south side of the outcrop ridge.

Heavy Mineral Recovery and Analysis

Samples of beach sand and till were processed by Overburden Drilling Management Ltd. of Nepean, Ontario to obtain heavy mineral concentrates. Sample processing involves initial disaggregation and screening after which the –2 mm fraction ("Table Feed" of Table 4) is passed over a shaking table twice to produce a "Table Concentrate" of heavy minerals ("Table Concentrate Total" of Table 4). At the tabling stage, a preliminary count of gold grains including size and shape determination is made. The "Table Concentrate" of samples containing gold identified at the preliminary stage is subsequently panned and examined under a microscope to provide a refined count of gold grains and description of grain shapes (Table 5). A concentrate of heavy minerals (HMC) having a specific gravity greater than 3.2 is obtained by gravity settling of the "Table Concentrate" in methylene iodide. The HMC is washed in oxalic acid and magnetic grains are subsequently removed. The non-magnetic component of the HMC

Table 1. Sample locations, descriptions and type of analyses, Kasabonika area.

Sample No.	UTM east	UTM north	Area	Description	Analysis requested
01DS06	391200	5935300	W. of Kasabonika	Gabbro	Assay for Pt, Pd, Au, Ni, Cu
01DS07	391050	5936700	W. of Kasabonika	Pyritic diorite	Assay for Pt, Pd, Au, Ni, Cu
01DS08	409150	5946700	NE of Kasabonika (Anderson Showing)	Foliated mafic metavolcanic rock	Major and trace elements
01DST10	395800	5933400	E. of Kasabonika	Beach sand	Indicators of kimberlite, metamorphosed or magmatic sulphide minerals and gold grains
01DST11	400300	5935500	E. of Kasabonika	Beach sand	Indicators of kimberlite, metamorphosed or magmatic sulphide minerals and gold grains
01DST12	404400	5939300	E. of Kasabonika	Beach sand	Indicators of kimberlite, metamorphosed or magmatic sulphide minerals and gold grains
01DST13	407250	5936900	E. of Kasabonika	Beach sand	Indicators of kimberlite, metamorphosed or magmatic sulphide minerals and gold grains
01DST14	391150	5936250	W. of Kasabonika at rapids	Fine beach sand with black layers containing garnet	Indicators of kimberlite, metamorphosed or magmatic sulphide minerals and gold grains
01DST15	392500	5932600	Kasabonika Island	Coarse beach sand	Indicators of kimberlite, metamorphosed or magmatic sulphide minerals and gold grains
01DST16	391000	5942000	NW of Kasabonika	Beach sand (Simon's sample 2)	Indicators of kimberlite, metamorphosed or magmatic sulphide minerals and gold grains
01DST17	392000	5938300	NW of Kasabonika	Beach sand (Simon's sample 3)	Indicators of kimberlite, metamorphosed or magmatic sulphide minerals and gold grains
01DST18	389000	5943000	NW of Kasabonika	Beach sand (Simon's sample 1)	Indicators of kimberlite, metamorphosed or magmatic sulphide minerals and gold grains
01DST20	409288	5946732	Anderson Showing, NE of Kasabonika	Grey silty till on bedrock, 0.5 m depth in bedrock crevasse	Indicators of kimberlite, metamorphosed or magmatic sulphide minerals and gold grains
01DST21	409105	5946687	Anderson Showing, NE of Kasabonika	Grey silty till on greenstone bedrock at 0.4 m depth below 0.2 m organic layer	Indicators of kimberlite, metamorphosed or magmatic sulphide minerals and gold grains
01DST22	408988	5946717	Anderson Showing, NE of Kasabonika	Grey silty till on greenstone bedrock, 0.3 m depth	Gold grain count and save heavy mineral concentrate
01DST23	408918	5946740	Anderson Showing, NE of Kasabonika	Grey silty till, 0.5 m depth	Gold grain count and save heavy mineral concentrate
01DST24	409034	5946718	Anderson Showing, NE of Kasabonika	Red weathered till at 0.5 m depth on bedrock	Gold grain count and save heavy mineral concentrate
01DST25	409206	5946700	Anderson Showing, NE of Kasabonika	Grey silty till, 0.5 m depth on boulders or bedrock	Gold grain count and save heavy mineral concentrate
01DST26	409381	5946742	Anderson Showing, NE of Kasabonika	Silty till with carbonate pebbles, 0.6 m depth	Gold grain count and save heavy mineral concentrate
01DST11b	400300	5935500	E. of Kasabonika	Pebble fraction of beach sand	Characterize pebble lithologies
01DST13b	407250	5936900	E. of Kasabonika	Pebble fraction of beach sand	Characterize pebble lithologies
01DST15b	392500	5932600	Kasabonika Island	Pebble fraction of coarse beach sand	Characterize pebble lithologies

Note: UTM co-ordinates are for Universal Transverse Mercator Grid Zone 16, NAD 27 projection.

Table 2. Analyses of rock samples from the Kasabonika area.

Sample / Rock	Method	Detection Limit	01DS06 / gabbro	01DS07 / pyritic diorite	01DS08 / mafic volcanic	
Area			W of Kas.	W. of Kas.	NE of Kas	
Easting			391200	391050	409150	
Northing			5935300	5936700	5946700	
SiO2 wt%	WD-XRF	0.01			54.12	
Al2O3	WD-XRF	0.01			14.67	
MnO	WD-XRF	0.01			0.16	
MgO	WD-XRF	0.01			6.65	
CaO	WD-XRF	0.01			9.29	
Na2O	WD-XRF	0.01			2.46	
K2O	WD-XRF	0.01			0.94	
TiO2	WD-XRF	0.01			0.68	
P2O5	WD-XRF	0.01			0.06	
Fe2O3T	WD-XRF	0.01			10.07	
LOI	WD-XRF	0.05			1.34	
Total					100.45	
CO2	IR Spectr.	0.03			0.1	
S	IR Spectr.	0.01			0.02	
FeO	Titrimetry	0.06				
Fe2O3	calc.	0.04				
H2O-	IR Phtmtry	0.01				
H2O+	IR Phtmtry	0.03				
Rb ppm	ICP-MS	0.20			34.94	
Ba	ICP-MS	5.00				
Sr	ICP-MS	2			149.66	
Cs	ICP-MS	0.08			0.82	
Be	ICP-OES	3			N.D.	
Mo	ICP-OES	8			N.D.	
Ta	ICP-MS	0.30			N.D.	
Hf	ICP-MS	0.10			1.8	
Nb	ICP-MS	0.08			2.77	
Zr	ICP-MS	6.00			68.35	
Co	ICP-OES	5			43	
Cr	ICP-MS	1			290.88	(66 by XRF)
Cu	ICP-OES	8	71	205	93	
Ni	ICP-OES	5	243	11	74	
V	ICP-OES	5			197	
Zn	ICP-OES	2			76	
Pb	XRF/ICP	7/.1				
Th	ICP-MS	0.05			1.59	
U	ICP-MS	0.01			0.47	
Sc	ICP-OES	5			28	
Y	ICP-OES	0			15.33	
Au ppb	ICP-MS	5 ppb	N.D.	N.D.		
Pd ppb	ICP-MS	8 ppb	N.D.	N.D.		
Pt ppb	ICP-MS	8 ppb	N.D.	N.D.		
La ppm	ICP-MS	0.2			6.72	
Ce	ICP-MS	0.3			14.91	
Pr	ICP-MS	0.03			1.91	
Nd	ICP-MS	0.2			7.78	
Sm	ICP-MS	0.03			2.03	
Eu	ICP-MS	0.004			0.68	
Gd	ICP-MS	0.03			2.45	
Tb	ICP-MS	0.001			0.42	
Dy	ICP-MS	0.01			2.76	
Ho	ICP-MS	0.01			0.58	
Er	ICP-MS	0.006			1.65	
Tm	ICP-MS	0.005			0.24	
Yb	ICP-MS	0.01			1.53	
Lu	ICP-MS	0.001			0.24	

ICP-MS = inductively coupled plasma mass spectrometry
ICP-OES = inductively coupled optical emission spectrometry
H2O+ = water combined within the lattice of silicate minerals and released above 110°C
H2O- = water present as dampness in the rock powder and driven off by heating below 110°C

IR Spectr. = infrared combustion
WD-XRF = X-ray fluorescence

Fe2O3 calc. = Fe2O3T - (FeO/ 899)

Fe2O3T = total iron
N.D. = not detected

Table 3. Distribution of pebble lithologies, Kasabonika area.

Sample	mafic volcanic	gabbro	intermediate volcanic	wacke	biotite tonalite	hornblende granite	biotite granite	mylonite	muscovite granite	quartz	red sandstone	limestone chert	total weight (gm)
01DST11b	232	16	13	331	38	41	371	36	na	13	53	102	1246
	18.62%	1.28%	1.04%	26.57%	3.05%	3.29%	29.78%	2.89%		1.04%	4.25%	8.19%	100.00%
01DST13b	125	na	na	751	230	74	382	na	10	na	49	31	1652
	7.57%			45.46%	13.92%	4.48%	23.12%		0.61%		2.97%	1.88%	100.00%
01DST15b	61	na	na	553	147	8	593	na	na	12	6	119	1499
	4.07%			36.89%	9.81%	0.53%	39.56%			0.80%	0.40%	7.94%	100.00%

Notes: Each sample represents approximately 300 to 500 pebbles in the 5 mm to 50 mm size range collected from beaches in the area of Kasabonika.
The pebbles of each type of rock are weighed separately and expressed as a percentage of the total weight.
na-absent from the sample.

Table 4. Processing data, Kasabonika samples.

Sample No.	Bulk Rec'd (kg)	Table Split (kg)	Clasts 2 mm+ (kg)	Table Feed (kg)		Table Concentrate Total (gm)	Heavy Liquid Lights (gm)	Total Magnetic (gm)	Total Non-Magnetic (gm)
01DST10	8.7	8.2	1.2	7		779.3	653.3	1.3	124.7
01DST11	6.7	6.2	2.8	3.4		729.1	693.6	1.1	34.4
01DST12	8.7	8.2	2.3	5.9		1159.4	1123.6	0.8	35
01DST13	7.9	7.4	1.7	5.7		1139.1	1093.4	1.6	44.1
01DST14	9.7	9.2	0.1	9.1		2432.9	175.5	1100.5	1156.9
01DST15	7.1	6.6	0.9	5.7		740.1	719.2	1	19.9
01DST16	4.7	4.2	0.4	3.8		800	792.1	0.4	7.5
01DST17	7.2	6.7	1.3	5.4		861.5	830.5	5.5	25.5
01DST18	5.5	5	0.8	4.2		1048.6	1032.9	0.8	14.9
01DST20	11.5	11.1	3.2	7.9		984.8	892.7	7.8	84.3
01DST21	13.1	12.6	1.6	11		870.1	844.2	4	21.9
01DST22	9.7	9.2	1.3	7.9		338.84	306.5	4.74	27.6
01DST23	9.8	9.3	0.6	8.7		299.9	275.3	5	19.6
01DST24	8.4	7.9	0.6	7.3		325.5	292.1	1.7	31.7
01DST25	8.4	8	0.9	7.1		360.1	320.8	5.3	34
01DST26	10.3	9.8	2.3	7.5		314.8	271.3	5.3	38.2

Table 5. Summary gold grain data, Kasabonika area.

Sample	Number of Visible Gold Grains				Non-Mag	Calculated PPB Visible Gold			
No.	Total	Reshaped	Modified	Pristine	Weight	Total	Reshaped	Modified	Pristine
01DST10	0	0	0	0	124.7	0	0	0	0
01DST11	0	0	0	0	34.4	0	0	0	0
01DST12	0	0	0	0	35	0	0	0	0
01DST13	0	0	0	0	44.1	0	0	0	0
01DST14	0	0	0	0	1156.9	0	0	0	0
01DST15	0	0	0	0	19.9	0	0	0	0
01DST16	0	0	0	0	7.5	0	0	0	0
01DST17	0	0	0	0	25.5	0	0	0	0
01DST18	0	0	0	0	14.9	0	0	0	0
01DST20	*0*	*0*	*0*	*0*	*84.3*	*0*	*0*	*0*	*0*
01DST21	*0*	*0*	*0*	*0*	*21.9*	*0*	*0*	*0*	*0*
01DST22	*1*	*1*	*0*	*0*	*31.6*	*6.74*	*6.74*	*0*	*0*
01DST23	*0*	*0*	*0*	*0*	*34.8*	*0*	*0*	*0*	*0*
01DST24	*0*	*0*	*0*	*0*	*29.2*	*0*	*0*	*0*	*0*
01DST25	*4*	*4*	*0*	*0*	*28.4*	*233.52*	*233.52*	*0*	*0*
01DST26	*0*	*0*	*0*	*0*	*30*	*0*	*0*	*0*	*0*

beach sand - regular font; *till - italics*

(Total Non-magnetic of Table 4) is sieved to 0.25, 0.5 and 1.0 mm fractions, which are further subdivided paramagnetically to provide small batches of grains for picking.

The components of the non-magnetic fraction of the heavy mineral concentrate were examined under a microscope by staff of Overburden Drilling Management Ltd. and indicator grains of metamorphosed or magmatic massive sulphide deposits (MMSIMs®*) and kimberlite (KIMs) were counted and placed in capsules (Tables 6 and 7). Mineral identification is done on the basis of physical characteristics of the mineral grains with resolution of more difficult grains by analysis of the energy spectrum produced by an x-ray spectrometer on a scanning electron microscope. The heavy mineral picking remarks (Table 8) include an estimate of the assemblage of minerals in the HMC and identification of grains whose composition is verified qualitatively by the scanning electron microscope.

Subsequent studies of mineral characteristics including the determination of mineral compositions are done at the Geoscience Laboratories, Ontario Geoservices Centre, Sudbury. Representative MMSIMs® and KIMs were examined by binocular microscope and the shape characteristics of chromite grains were studied and photographed by scanning electron microscope.

The majority of KIMs and MMSIMs® identified by Overburden Drilling Management Ltd. were mounted in epoxy and polished and analysed by microprobe. Mineral compositions are listed in Table 9. The microprobe calibration routine and operating conditions are summarised in the *Standard Operating Procedures Manual* and the *Methods Manual for the Analysis of Kimberlite Indicator Minerals* of the Geoscience Laboratories, Sudbury, Ontario.

Results

ROCK ANALYSES

Outcrops of gabbro and diorite 3 to 5 km northwest of Kasabonika contain local disseminations of sulphide minerals and were sampled for analysis of selected base metals and precious metals. The results for samples 01DS06 and 01DS07 (*see* Figure 2 and Table 2) show low levels of Cu and Ni (>244 ppm) and concentrations of Au, Pt and Pd that are below the detection limit for the analytical method.

Sample 01DS08 was collected from an outcrop of black, foliated amphibolite of probable volcanic origin in the area of the Anderson Showing (*see* Figure 2). The amphibolite is classified as a high-magnesium tholeiite on the basis of major element content (Figure 3a). The sample shows a primitive-mantle normalized trace-element pattern that is sloped from left to right (Figure 3b) due to enrichment in Th and light rare earth elements such as La and Ce relative to heavy rare earth elements such as Yb and Lu. The trace element pattern for sample 01DS08 has troughs corresponding to Nb and Ti and is characteristic of the trace element distribution in basalts erupted at volcanic arcs (Pearce 1996). Alternatively, contamination of a primitive basaltic magma with crustal material may account for the trace element characteristics of sample 01DS08. Crustal material such as tonalite is enriched in Th and light rare earth elements and depleted in Nb and Ti, and can produce a trace element profile such as in Figure 3b when mixed with a non-enriched basalt. Somewhat high levels of SiO_2 and Na_2O in the basalt imply that some contamination by tonalitic material could have taken place.

*MMSIM is a registered trademark of Overburden Drilling Management Limited, Nepean, Ontario.

Table 6. Metamorphosed or magmatic sulphide indicator minerals (MMSIMs®), Kasabonika area.

	Sulphide/Arsenide + Related Minerals 0.25-0.5 mm				Mg/Mn/Al/Cr Minerals 0.25-0.5 mm											
	>1 amp			<1.0 amp	>1.0 amp					>0.8 amp	<0.8 amp				>1.0 amp	
Sample No.	%Ccp	Misc. Prime MMSIMs	% Py	%Gth	Spinel; # Grains + Colour	Misc. Prime MMSIMs	% Red Rutile	% Ky	% Sil	% St	% Sps	% Fay	% Opx	% Cr	Carbonate Minerals	Total MMSIMs
01DST10	Tr (4 gr)	0	Tr (10 gr)	Tr	9 grey-blue, pale grey, pale pink	Tr Mn-epidote (4 gr), Tr low-Cr diopside (6 gr)	0	2	Tr	Tr	0	0	3	0	0	14
01DST11	Tr (1 gr)	0	0	0	0	0	0	1	0	0	0	0	Tr	0	0	1
01DST12	0	0	0	Tr	0	0	0	0.5	Tr	0	0	0	0.5	0	0	0
01DST13	0	0	0	Tr	0	Tr low-Cr diopside (5 gr)	0	Tr	0	Tr	0	0	0	0	0	5
01DST14	Tr (3 gr)	0	Tr (~50 gr)	Tr	4 blue-green, gahnite; 13 blue, pale purple, blue-green spinel	Tr ruby corundum (3 gr), Tr low-Cr diopside (1 gr)	Tr (~100 gr)	3	Tr	8	Tr	0	Tr	Tr (~70 gr, see KIM data)	0	~110
01DST15	0	0	Tr (1 gr)	Tr	0	Tr low-Cr diopside (1 gr)	0	1	0	Tr	0	0	3	0	0	1
01DST16	0	0	0	Tr	0	0	0	Tr	0	Tr	0	0	0	0	0	0
01DST17	Tr (1 gr)	0	Tr (5 gr)	Tr	0	Tr low-Cr diopside (1 gr)	0	0.5	0	Tr	0	0	1	0	0	2
01DST18	Tr (1 gr)	0	0	Tr	0	Tr low-Cr diopside (1 gr)	0	1	0	Tr	0	0	Tr	0	0	2
01DST20	0	0	0	Tr	0	0	0	Tr	0	Tr	0	0	0	0	0	0
01DST21	0	0	Tr (2 gr)	Tr	0	Tr low-Cr diopside (2 gr)	0	Tr	0	Tr	0	0	Tr	0	0	2

Samples 01DST22 to 01DST26 were not picked for MMSIMs®.
Abbreviations: Ccp-chalcopyrite; Py-pyrite; Gth-goethite; Ky-kyanite; Sil-sillimanite; St-staurolite; Sps-spessartine; Fay-fayalite; Opx-orthopyroxene; Cr-chromite.
Tr-trace; gr-grains.

Table 7. Kimberlite indicator mineral counts, Kasabonika samples.

Sample No.	KIM Count (* species not rigorously picked; excluded from total) 1.0 to 2.0 mm						0.5 to 1.0 mm						0.25 to 0.5 mm							Lo Cr Di
	GP	GO	DC	IM	CR	FO*	GP	GO	DC	IM	CR	FO*	GP	GO*	DC	IM*	CR ***	FO*	**Total KIMs**	
01DST10	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	**3**	6
01DST11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**	0
01DST12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**	0
01DST13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**	5
01DST14	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	11(70)	0	**72**	1
01DST15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**	1
01DST16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**	0
01DST17	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	**1**	1
01DST18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**	1
01DST20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**	0
01DST21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**	2

Samples 01DST22 to 01DST26 were not picked for kimberlite indicators.
*** Numbers in brackets are estimated total indicator grains present in samples where not all of the grains were picked.
Abbreviations: GP - garnet pyrope; GO - garnet orange; DC - chrome diopside; IM - ilmenite; FO - forsterite; Lo Cr Di - low chrome diopside

Table 8. Picking remarks, Kasabonika samples. (Abbreviations as for Table 7.)

Sample No.	Kimberlite Indicator Picking Remarks
01DST10	SEM checks from 0.25-0.5 mm fraction: 2 GP versus almandine candidates = 1 GP and 1 almandine.
01DST11	No KIM remarks.
01DST12	No KIM remarks.
01DST13	No KIM remarks.
01DST14	SEM check from 0.5-1.0 mm fraction: 1 IM versus crustal ilmenite candidate = 1 IM. SEM checks from 0.25-0.5 mm fraction: 8 IM versus crustal ilmenite candidates = 2 CR and 6 crustal ilmenite.
01DST15	SEM check from 0.25-0.5 mm fraction: 1 composite CR + serpentine candidate = 1 crustal ilmenite + titanite.
01DST16	No KIM remarks.
01DST17	No KIM remarks.
01DST18	No KIM remarks.
01DST20	No KIM remarks.
01DST21	No KIM remarks.

Sample No.	MMSIM Picking Remarks
01DST10	Hornblende/epidote-titanite assemblage.
01DST11	Hornblende/epidote assemblage. SEM checks from 0.25-0.5 mm fraction: 1 earthy blue-green Cu-oxide candidate = 1 pumpellyite; and 2 columbite versus tourmaline candidates = 2 tourmaline.
01DST12	Hornblende/epidote assemblage.
01DST13	Hornblende/epidote-diopside-titanite assemblage.
01DST14	Almandine-hematite-ilmenite/epidote-diopside-titanite assemblage. SEM checks from 0.25-0.5 mm fraction: 4 blue-green gahnite versus spinel candidates = 3 gahnite and 1 spinel.
01DST15	Hornblende/epidote-diopside assemblage.
01DST16	Hornblende/epidote-diopside assemblage.
01DST17	Hornblende/epidote-diopside assemblage.
01DST18	Hornblende/epidote-diopside-titanite assemblage.
01DST20	Hornblende/epidote-titanite assemblage.
01DST21	Hornblende/epidote-diopside assemblage.

Table 9. Mineral chemistry of MMSIM®, KIM and crustal grains in surficial materials.

Spinel

Sample	Probe No.	SiO2	TiO2	Nb2O5	Al2O3	Cr2O3	V2O5	MgO	MnO	FeO*	NiO	ZnO	Total
01DST14	2	0.01	0.01	0.05	69.46	0.06	0.03	25.46	0.02	5.17	0.01	0.26	100.53
01DST14	3	0.03	0.01	0.00	69.23	0.05	0.02	24.89	0.25	5.83	0.00	0.03	100.33
01DST14	4	0.02	0.02	0.00	69.49	0.07	0.00	25.67	0.08	4.85	0.00	0.10	100.29
01DST14	5	0.04	0.00	0.00	69.31	0.05	0.05	24.37	0.08	6.27	0.00	0.11	100.28
01DST14	6	0.03	0.06	0.03	69.70	0.07	0.05	25.56	0.04	4.32	0.01	0.16	100.02
01DST14	7	0.04	0.03	0.00	69.07	0.09	0.04	25.33	0.08	4.94	0.00	0.11	99.72
01DST14	9	0.00	0.01	0.01	69.16	0.00	0.00	24.54	0.06	6.03	0.00	0.11	99.91
01DST14	10	0.00	0.02	0.00	68.90	0.06	0.05	24.97	0.10	5.64	0.01	0.11	99.86
Gahnite													
01DST14	8	0.01	0.01	0.05	57.30	0.01	0.00	1.96	0.07	7.73	0.00	33.46	100.59
01DST14	11	0.03	0.00	0.00	56.82	0.00	0.00	2.48	0.44	9.32	0.00	31.32	100.40
01DST14	12	0.02	0.00	0.00	58.10	0.00	0.01	2.77	0.35	13.88	0.00	25.80	100.94
01DST14	13	0.00	0.01	0.01	56.16	0.02	0.05	1.69	0.11	6.21	0.00	36.52	100.78

Clinopyroxenes

Sample	Probe No.	SiO2	TiO2	Al2O3	Cr2O3	MgO	CaO	MnO	FeO	Na2O	K2O	Total
01DST21	2	53.74	0.14	1.71	0.65	16.38	23.36	0.14	3.92	0.48	0.00	100.51
01DST21	1	54.68	0.08	1.25	0.58	17.48	21.49	0.15	4.18	0.49	0.00	100.38
01DST18	1	53.83	0.04	1.23	0.46	16.44	22.83	0.14	4.64	0.50	0.00	100.09
01DST17	2	53.14	0.12	1.43	0.61	16.88	23.65	0.10	3.09	0.40	0.00	99.42
01DST15	2	53.87	0.04	1.47	0.28	16.37	23.38	0.11	3.75	0.47	0.00	99.73
01DST14	65	51.20	0.38	3.26	0.49	15.17	23.11	0.16	5.51	0.27	0.00	99.54
01DST14	61	51.33	0.54	2.19	0.34	16.00	20.67	0.20	7.79	0.25	0.00	99.32
01DST14	60	51.21	0.49	3.12	0.29	17.17	19.05	0.19	7.32	0.25	0.00	99.09
01DST14	59	52.20	0.31	2.13	0.05	14.20	20.17	0.27	9.68	0.25	0.01	99.27
01DST14	53	51.75	0.59	1.52	0.07	15.40	17.89	0.29	11.91	0.21	0.00	99.63
01DST14	**46**	**51.89**	**0.10**	**2.03**	**0.27**	**14.00**	**20.18**	**0.27**	**10.31**	**0.74**	**0.00**	**99.79**
01DST14	43	52.25	0.12	1.24	0.03	12.27	22.82	0.37	9.88	0.67	0.00	99.64
01DST14	40	53.53	0.09	0.93	0.09	15.12	23.17	0.44	6.23	0.56	0.00	100.15
01DST14	39	51.81	0.22	1.55	0.00	12.90	21.56	0.67	9.97	0.60	0.00	99.27
01DST14	38	52.83	0.05	0.94	0.03	13.17	23.66	0.55	8.37	0.44	0.01	100.04
01DST14	37	54.39	0.02	1.01	0.60	16.27	23.00	0.27	3.89	0.59	0.00	100.04
01DST13	**4**	**54.32**	**0.02**	**1.00**	**0.55**	**16.85**	**23.04**	**0.16**	**3.72**	**0.53**	**0.00**	**100.19**
01DST13	**3**	**54.51**	**0.07**	**0.75**	**0.32**	**16.86**	**23.03**	**0.11**	**3.81**	**0.48**	**0.00**	**99.94**
01DST13	2	54.69	0.03	0.85	0.33	18.76	20.03	0.15	5.36	0.43	0.00	100.64
01DST13	**1**	**54.01**	**0.07**	**2.00**	**0.77**	**17.03**	**22.71**	**0.09**	**3.07**	**0.59**	**0.00**	**100.35**
01DST10	**9**	**53.06**	**0.13**	**1.83**	**1.02**	**15.38**	**22.55**	**0.35**	**4.51**	**0.68**	**0.00**	**99.51**
01DST10	**8**	**52.76**	**0.12**	**3.69**	**0.55**	**15.36**	**22.79**	**0.09**	**3.13**	**0.87**	**0.01**	**99.35**
01DST10	7	54.14	0.07	1.38	0.63	16.78	23.80	0.09	2.80	0.43	0.00	100.11
01DST10	6	54.50	0.04	0.60	0.27	16.54	24.73	0.10	2.93	0.35	0.00	100.05
01DST10	5	54.07	0.05	0.99	0.85	16.39	22.85	0.19	3.88	0.60	0.01	99.88
01DST10	**4**	**53.80**	**0.04**	**1.29**	**0.91**	**17.59**	**21.08**	**0.10**	**3.95**	**0.73**	**0.00**	**99.50**
Orthopyroxene												
01DST14	69	52.03	0.10	0.84	0.02	19.50	1.02	0.71	26.15	0.00	0.00	100.38
01DST14	52	50.04	0.06	0.61	0.02	15.78	0.84	1.06	30.96	0.00	0.00	99.38

kimberlite indicator

Table 9. Mineral chemistry of MMSIM's, KIM and crustal grains in surficial materials

Spinel

Sample	Probe No.	SiO2	TiO2	Nb2O5	Al2O3	Cr2O3	V2O5	MgO	MnO	FeO*	NiO	ZnO	Total
01DST14	2	0.01	0.01	0.05	69.46	0.06	0.03	25.46	0.02	5.17	0.01	0.26	100.53
01DST14	3	0.03	0.01	0.00	69.23	0.05	0.02	24.89	0.25	5.83	0.00	0.03	100.33
01DST14	4	0.02	0.02	0.00	69.49	0.07	0.00	25.67	0.08	4.85	0.00	0.10	100.29
01DST14	5	0.04	0.00	0.00	69.31	0.05	0.05	24.37	0.08	6.27	0.00	0.11	100.28
01DST14	6	0.03	0.06	0.03	69.70	0.07	0.05	25.56	0.04	4.32	0.01	0.16	100.02
01DST14	7	0.04	0.03	0.00	69.07	0.09	0.04	25.33	0.08	4.94	0.00	0.11	99.72
01DST14	9	0.00	0.01	0.01	69.16	0.00	0.00	24.54	0.06	6.03	0.00	0.11	99.91
01DST14	10	0.00	0.02	0.00	68.90	0.06	0.05	24.97	0.10	5.64	0.01	0.11	99.86
Gahnite													
01DST14	8	0.01	0.01	0.05	57.30	0.01	0.00	1.96	0.07	7.73	0.00	33.46	100.59
01DST14	11	0.03	0.00	0.00	56.82	0.00	0.00	2.48	0.44	9.32	0.00	31.32	100.40
01DST14	12	0.02	0.00	0.00	58.10	0.00	0.01	2.77	0.35	13.88	0.00	25.80	100.94
01DST14	13	0.00	0.01	0.01	56.16	0.02	0.05	1.69	0.11	6.21	0.00	36.52	100.78

Clinopyroxenes

Sample	Probe No.	SiO2	TiO2	Al2O3	Cr2O3	MgO	CaO	MnO	FeO	Na2O	K2O	Total
01DST21	2	53.74	0.14	1.71	0.65	16.38	23.36	0.14	3.92	0.48	0.00	100.51
01DST21	1	54.68	0.08	1.25	0.58	17.48	21.49	0.15	4.18	0.49	0.00	100.38
01DST18	1	53.83	0.04	1.23	0.46	16.44	22.83	0.14	4.64	0.50	0.00	100.09
01DST17	2	53.14	0.12	1.43	0.61	16.88	23.65	0.10	3.09	0.40	0.00	99.42
01DST15	2	53.87	0.04	1.47	0.28	16.37	23.38	0.11	3.75	0.47	0.00	99.73
01DST14	65	51.20	0.38	3.26	0.49	15.17	23.11	0.16	5.51	0.27	0.00	99.54
01DST14	61	51.33	0.54	2.19	0.34	16.00	20.67	0.20	7.79	0.25	0.00	99.32
01DST14	60	51.21	0.49	3.12	0.29	17.17	19.05	0.19	7.32	0.25	0.00	99.09
01DST14	59	52.20	0.31	2.13	0.05	14.20	20.17	0.27	9.68	0.25	0.01	99.27
01DST14	53	51.75	0.59	1.52	0.07	15.40	17.89	0.29	11.91	0.21	0.00	99.63
01DST14	**46**	**51.89**	**0.10**	**2.03**	**0.27**	**14.00**	**20.18**	**0.27**	**10.31**	**0.74**	**0.00**	**99.79**
01DST14	43	52.25	0.12	1.24	0.03	12.27	22.82	0.37	9.88	0.67	0.00	99.64
01DST14	40	53.53	0.09	0.93	0.09	15.12	23.17	0.44	6.23	0.56	0.00	100.15
01DST14	39	51.81	0.22	1.55	0.00	12.90	21.56	0.67	9.97	0.60	0.00	99.27
01DST14	38	52.83	0.05	0.94	0.03	13.17	23.66	0.55	8.37	0.44	0.01	100.04
01DST14	37	54.39	0.02	1.01	0.60	16.27	23.00	0.27	3.89	0.59	0.00	100.04
01DST13	**4**	**54.32**	**0.02**	**1.00**	**0.55**	**16.85**	**23.04**	**0.16**	**3.72**	**0.53**	**0.00**	**100.19**
01DST13	**3**	**54.51**	**0.07**	**0.75**	**0.32**	**16.86**	**23.03**	**0.11**	**3.81**	**0.48**	**0.00**	**99.94**
01DST13	2	54.69	0.03	0.85	0.33	18.76	20.03	0.15	5.36	0.43	0.00	100.64
01DST13	**1**	**54.01**	**0.07**	**2.00**	**0.77**	**17.03**	**22.71**	**0.09**	**3.07**	**0.59**	**0.00**	**100.35**
01DST10	**9**	**53.06**	**0.13**	**1.83**	**1.02**	**15.38**	**22.55**	**0.35**	**4.51**	**0.68**	**0.00**	**99.51**
01DST10	**8**	**52.76**	**0.12**	**3.69**	**0.55**	**15.36**	**22.79**	**0.09**	**3.13**	**0.87**	**0.01**	**99.35**
01DST10	7	54.14	0.07	1.38	0.63	16.78	23.80	0.09	2.80	0.43	0.00	100.11
01DST10	6	54.50	0.04	0.60	0.27	16.54	24.73	0.10	2.93	0.35	0.00	100.05
01DST10	5	54.07	0.05	0.99	0.85	16.39	22.85	0.19	3.88	0.60	0.01	99.88
01DST10	**4**	**53.80**	**0.04**	**1.29**	**0.91**	**17.59**	**21.08**	**0.10**	**3.95**	**0.73**	**0.00**	**99.50**
Orthopyroxene												
01DST14	69	52.03	0.10	0.84	0.02	19.50	1.02	0.71	26.15	0.00	0.00	100.38
01DST14	52	50.04	0.06	0.61	0.02	15.78	0.84	1.06	30.96	0.00	0.00	99.38

kimberlite indicator

Orthopyroxene (cont'd.)

Sample	Probe No.	SiO2	TiO2	Al2O3	Cr2O3	MgO	CaO	MnO	FeO	Na2O	K2O	Total
01DST14	70	51.08	0.10	0.86	0.03	18.22	0.79	0.78	28.05	0.00	0.00	99.91
01DST14	64	50.81	0.10	0.59	0.01	17.77	0.69	1.16	28.50	0.00	0.00	99.62
01DST14	49	52.56	0.09	0.81	0.01	21.68	0.60	0.85	23.62	0.00	0.00	100.21
01DST14	54	51.96	0.12	1.00	0.03	20.28	0.56	0.76	25.42	0.00	0.00	100.13
01DST14	55	52.19	0.06	4.20	0.02	26.19	0.56	0.38	17.11	0.00	0.00	100.71
01DST14	58	53.43	0.07	0.73	0.02	22.10	0.54	1.07	22.94	0.00	0.00	100.89
01DST14	51	51.68	0.09	1.32	0.00	20.70	0.53	0.69	24.72	0.00	0.00	99.73
01DST14	56	52.67	0.10	0.82	0.02	21.90	0.50	0.87	23.33	0.00	0.00	100.20
01DST14	62	54.59	0.07	1.33	0.25	28.07	0.37	0.27	15.49	0.00	0.00	100.45
01DST14	57	50.01	0.08	2.16	0.01	19.04	0.18	0.49	27.01	0.00	0.00	98.97

Garnet

Sample	Probe No.	SiO2	TiO2	Al2O3	Cr2O3	MgO	CaO	MnO	FeO	Na2O	K2O	Total
01DST10	**1**	**41.22**	**0.00**	**20.93**	**3.85**	**19.41**	**6.15**	**0.48**	**7.83**	**0.00**	**0.00**	**99.87**
01DST10	**2**	**41.28**	**0.00**	**20.89**	**3.92**	**19.52**	**6.08**	**0.47**	**7.83**	**0.00**	**0.00**	**100.00**
01DST10	**3**	**41.48**	**0.04**	**21.80**	**2.58**	**19.74**	**5.26**	**0.46**	**8.58**	**0.00**	**0.00**	**99.94**
01DST14	**1**	**41.64**	**0.11**	**21.43**	**2.80**	**20.75**	**4.70**	**0.41**	**8.23**	**0.02**	**0.00**	**100.09**
01DST17	**1**	**40.89**	**0.30**	**19.90**	**4.93**	**20.32**	**4.94**	**0.43**	**7.95**	**0.04**	**0.00**	**99.69**

Chromite

Sample	Probe No.	SiO2	TiO2	Nb2O5	Al2O3	Cr2O3	V2O5	MgO	MnO	FeO*	NiO	ZnO	Total	Fe2O3	FeO	Total	Roundness
01DST14	**21**	**0.05**	**0.36**	**0.01**	**14.42**	**52.25**	**0.19**	**10.53**	**0.23**	**21.72**	**0.07**	**0.10**	**99.92**	**3.49**	**18.58**	**100.27**	**subround**
01DST14	22	0.18	0.82	0.01	30.41	34.31	0.11	16.37	0.13	17.50	0.25	0.06	100.13	5.35	12.69	100.67	subround
01DST14	24	0.19	1.23	0.00	30.18	34.90	0.09	13.90	0.16	17.84	0.21	0.08	98.77	1.73	16.28	98.94	round
01DST14	25	0.07	0.48	0.04	13.30	50.50	0.18	7.92	0.37	26.79	0.06	0.08	99.77	4.86	22.41	100.26	round
01DST14	26	0.15	0.33	0.00	6.88	52.03	0.01	4.73	0.46	33.90	0.10	0.40	98.98	9.51	25.34	99.93	angular
01DST14	27	0.05	0.48	0.02	15.60	43.97	0.19	8.15	0.40	30.67	0.13	0.15	99.81	9.29	22.31	100.74	subangular
01DST14	28	0.03	0.21	0.00	11.55	43.28	0.20	6.81	0.33	36.35	0.15	0.10	99.01	14.41	23.38	100.46	subangular
01DST14	**29**	**0.15**	**1.19**	**0.01**	**18.13**	**46.18**	**0.16**	**14.27**	**0.18**	**19.84**	**0.13**	**0.04**	**100.27**	**5.96**	**14.48**	**100.87**	**subangular**
01DST14	30	0.08	0.50	0.05	16.31	46.86	0.14	6.82	0.36	29.01	0.09	0.10	100.32	4.82	24.67	100.81	subangular
01DST14	**31**	**0.12**	**4.85**	**0.01**	**7.52**	**40.60**	**0.10**	**13.26**	**0.22**	**32.12**	**0.20**	**0.03**	**99.03**	**16.61**	**17.18**	**100.69**	**subangular**
01DST14	**32**	**0.06**	**0.22**	**0.05**	**18.87**	**47.80**	**0.16**	**12.11**	**0.36**	**20.44**	**0.12**	**0.10**	**100.28**	**4.17**	**16.69**	**100.70**	**subangular**

Picro-Ilmenite

Sample	Probe No.	SiO2	TiO2	Nb2O5	Al2O3	Cr2O3	V2O5	MgO	MnO	FeO*	NiO	ZnO	Total	Fe2O3	FeO	Total	ilmenite	geikelite	hematite
01DST14	**20**	**0.00**	**51.02**	**0.07**	**0.11**	**3.17**	**0.33**	**10.37**	**0.34**	**34.37**	**0.12**	**0.00**	**99.90**	**7.59**	**27.54**	**100.66**	**55.72**	**37.37**	**6.91**
Ilmenite																			
01DST14	14	0.01	51.18	0.00	0.00	0.00	0.00	0.05	4.98	43.57	0.00	0.21	100.00	3.17	40.71	100.31	96.40	0.22	3.38
01DST14	15	0.03	50.97	0.21	0.00	0.01	0.00	0.04	3.61	45.12	0.00	0.05	100.05	3.11	42.32	100.36	96.63	0.18	3.20
01DST14	16	0.01	50.32	0.05	0.01	0.01	0.23	0.10	1.30	47.79	0.01	0.03	99.85	4.05	44.14	100.26	95.65	0.40	3.95
01DST14	17	0.03	50.70	0.00	0.04	0.05	0.31	0.59	0.88	47.00	0.00	0.00	99.60	3.14	44.17	99.91	94.73	2.24	3.03
01DST14	18	0.04	51.03	0.09	0.03	0.01	0.11	0.03	6.68	42.17	0.00	0.00	100.18	3.10	39.38	100.49	96.46	0.12	3.42
01DST14	19	0.02	49.97	0.10	0.01	0.00	0.07	0.06	1.64	47.79	0.00	0.01	99.67	4.87	43.41	100.16	95.00	0.21	4.79
01DST14	33	0.06	51.81	0.07	0.01	0.06	0.06	0.22	0.42	47.20	0.00	0.03	99.93	1.33	46.00	100.06	97.92	0.82	1.27
01DST14	36	0.02	47.31	0.00	0.01	0.06	0.22	0.58	0.49	50.29	0.00	0.01	98.99	9.90	41.39	99.98	88.29	2.21	9.50
01DST15	1	0.04	50.78	0.13	0.01	0.02	0.00	0.02	2.69	46.24	0.00	0.01	99.94	3.51	43.08	100.29	96.37	0.10	3.54

Orthopyroxene (cont'd.)

Sample	Probe No.	SiO2	TiO2	Al2O3	Cr2O3	MgO	CaO	MnO	FeO	Na2O	K2O	Total
01DST14	70	51.08	0.10	0.86	0.03	18.22	0.79	0.78	28.05	0.00	0.00	99.91
01DST14	64	50.81	0.10	0.59	0.01	17.77	0.69	1.16	28.50	0.00	0.00	99.62
01DST14	49	52.56	0.09	0.81	0.01	21.68	0.60	0.85	23.62	0.00	0.00	100.21
01DST14	54	51.96	0.12	1.00	0.03	20.28	0.56	0.76	25.42	0.00	0.00	100.13
01DST14	55	52.19	0.06	4.20	0.02	26.19	0.56	0.38	17.11	0.00	0.00	100.71
01DST14	58	53.43	0.07	0.73	0.02	22.10	0.54	1.07	22.94	0.00	0.00	100.89
01DST14	51	51.68	0.09	1.32	0.00	20.70	0.53	0.69	24.72	0.00	0.00	99.73
01DST14	56	52.67	0.10	0.82	0.02	21.90	0.50	0.87	23.33	0.00	0.00	100.20
01DST14	62	54.59	0.07	1.33	0.25	28.07	0.37	0.27	15.49	0.00	0.00	100.45
01DST14	57	50.01	0.08	2.16	0.01	19.04	0.18	0.49	27.01	0.00	0.00	98.97

Garnet

Sample	Probe No.	SiO2	TiO2	Al2O3	Cr2O3	MgO	CaO	MnO	FeO	Na2O	K2O	Total
01DST10	1	41.22	0.00	20.93	3.85	19.41	6.15	0.48	7.83	0.00	0.00	99.87
01DST10	2	41.28	0.00	20.89	3.92	19.52	6.08	0.47	7.83	0.00	0.00	100.00
01DST10	3	41.48	0.04	21.80	2.58	19.74	5.26	0.46	8.58	0.00	0.00	99.94
01DST14	1	41.64	0.11	21.43	2.80	20.75	4.70	0.41	8.23	0.02	0.00	100.09
01DST17	1	40.89	0.30	19.90	4.93	20.32	4.94	0.43	7.95	0.04	0.00	99.69

Chromite

Sample	Probe No.	SiO2	TiO2	Nb2O5	Al2O3	Cr2O3	V2O5	MgO	MnO	FeO*	NiO	ZnO	Total	Fe2O3	FeO	Total	Roundness
01DST14	21	0.05	0.36	0.01	14.42	52.25	0.19	10.53	0.23	21.72	0.07	0.10	99.92	3.49	18.58	100.27	subround
01DST14	22	0.18	0.82	0.01	30.41	34.31	0.11	16.37	0.13	17.50	0.25	0.06	100.13	5.35	12.69	100.67	subround
01DST14	24	0.19	1.23	0.00	30.18	34.90	0.09	13.90	0.16	17.84	0.21	0.08	98.77	1.73	16.28	98.94	round
01DST14	25	0.07	0.48	0.04	13.30	50.50	0.18	7.92	0.37	26.79	0.06	0.08	99.77	4.86	22.41	100.26	round
01DST14	26	0.15	0.33	0.00	6.88	52.03	0.01	4.73	0.46	33.90	0.10	0.40	98.98	9.51	25.34	99.93	angular
01DST14	27	0.05	0.48	0.02	15.60	43.97	0.19	8.15	0.40	30.67	0.13	0.15	99.81	9.29	22.31	100.74	subangular
01DST14	28	0.03	0.21	0.00	11.55	43.28	0.20	6.81	0.33	36.35	0.15	0.10	99.01	14.41	23.38	100.46	subangular
01DST14	29	0.15	1.19	0.01	18.13	46.18	0.16	14.27	0.18	19.84	0.13	0.04	100.27	5.96	14.48	100.87	subangular
01DST14	30	0.08	0.50	0.05	16.31	46.86	0.14	6.82	0.36	29.01	0.09	0.10	100.32	4.82	24.67	100.81	subangular
01DST14	31	0.12	4.85	0.01	7.52	40.60	0.10	13.26	0.22	32.12	0.20	0.03	99.03	16.61	17.18	100.69	subangular
01DST14	32	0.06	0.22	0.05	18.87	47.80	0.16	12.11	0.36	20.44	0.12	0.10	100.28	4.17	16.69	100.70	subangular

Picro-Ilmenite

Sample	Probe No.	SiO2	TiO2	Nb2O5	Al2O3	Cr2O3	V2O5	MgO	MnO	FeO*	NiO	ZnO	Total	Fe2O3	FeO	Total	ilmenite	geikelite	hematite
01DST14	20	0.00	51.02	0.07	0.11	3.17	0.33	10.37	0.34	34.37	0.12	0.00	99.90	7.59	27.54	100.66	55.72	37.37	6.91
Ilmenite																			
01DST14	14	0.01	51.18	0.00	0.00	0.00	0.00	0.05	4.98	43.57	0.00	0.21	100.00	3.17	40.71	100.31	96.40	0.22	3.38
01DST14	15	0.03	50.97	0.21	0.00	0.01	0.00	0.04	3.61	45.12	0.00	0.05	100.05	3.11	42.32	100.36	96.63	0.18	3.20
01DST14	16	0.01	50.32	0.05	0.01	0.01	0.23	0.10	1.30	47.79	0.01	0.03	99.85	4.05	44.14	100.26	95.65	0.40	3.95
01DST14	17	0.03	50.70	0.00	0.04	0.05	0.31	0.59	0.88	47.00	0.00	0.00	99.60	3.14	44.17	99.91	94.73	2.24	3.03
01DST14	18	0.04	51.03	0.09	0.03	0.01	0.11	0.03	6.68	42.17	0.00	0.00	100.18	3.10	39.38	100.49	96.46	0.12	3.42
01DST14	19	0.02	49.97	0.10	0.01	0.00	0.07	0.06	1.64	47.79	0.00	0.01	99.67	4.87	43.41	100.16	95.00	0.21	4.79
01DST14	33	0.06	51.81	0.07	0.01	0.06	0.06	0.22	0.42	47.20	0.00	0.03	99.93	1.33	46.00	100.06	97.92	0.82	1.27
01DST14	36	0.02	47.31	0.00	0.01	0.06	0.22	0.58	0.49	50.29	0.00	0.01	98.99	9.90	41.39	99.98	88.29	2.21	9.50
01DST15	1	0.04	50.78	0.13	0.01	0.02	0.00	0.02	2.69	46.24	0.00	0.01	99.94	3.51	43.08	100.29	96.37	0.10	3.54

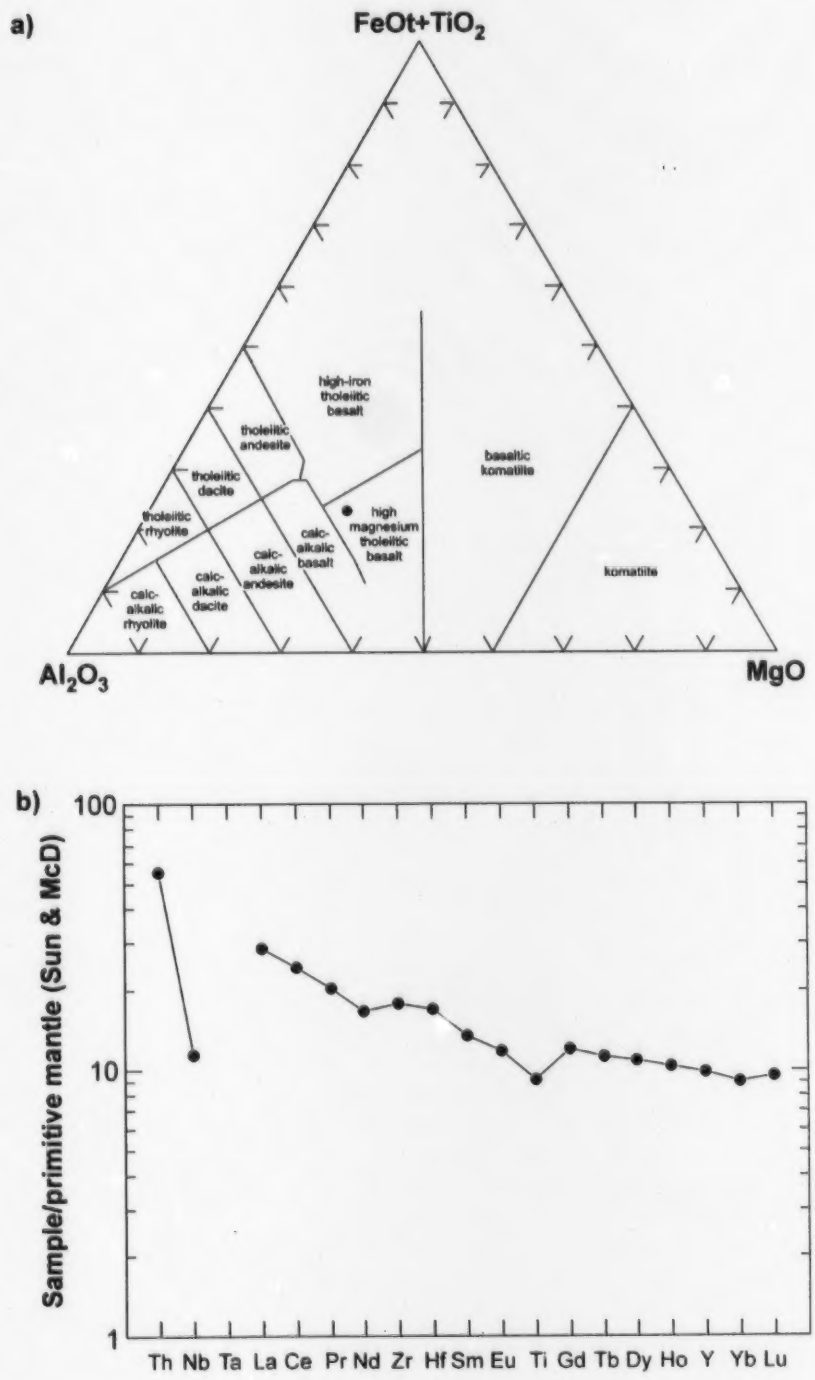

Figure 3. (a) Classification of sample 01DS08 using the cation diagram of Jensen (1976). (FeOt = total iron) (b) Trace element pattern of sample 01DS08 normalized to primitive mantle using values of Sun and McDonough (1989).

ANALYSIS OF PEBBLE LITHOLOGY

In areas devoid of exposed bedrock, the distribution of rock types represented by pebbles in beach deposits provides an indication of the local and regional bedrock geology. The pebbles in three samples from Kasabonika Lake are composed of mainly wacke and biotite granite with lesser mafic volcanic and biotite tonalite as well as accessory lithologies (*see* Table 3). In comparison with Figure 2, the proportions of major pebble lithologies provide a good correlation with the bedrock geology as determined from sparse outcrops. The sample sites overly a belt of metasedimentary and mafic metavolcanic rocks and adjacent undefined plutonic rocks that appear to account for the dominant pebble fractions. Evidently, most pebbles have been transported only a few kilometers from their bedrock source.

Red sandstone and limestone/chert clasts of probable Paleozoic age comprise 5% to 12% of the pebble fraction. These clasts are interpreted to indicate that a small but significant component of the surficial materials at Kasabonika have been transported distances on the order of 60 km southwesterly from the Hudson Bay lowlands. Rare clasts of gabbro, intermediate volcanic, mylonite, muscovite granite and quartz allude to the occurrence of these lithologies in bedrock of the area. Mylonite clasts provide evidence for faults in the area.

GOLD

No gold grains were identified in beach sand samples whereas two of the 7 till samples yielded 1 and 4 gold grains, respectively (*see* Table 5). The gold grains are classified as reshaped, which implies that the grains have the form of rounded or infolded nuggets (DiLabio 1990).

Low numbers of gold grains and the absence of gold grains in beach sands are typical of sampling surveys in the northern Superior Province of Ontario (Stone 1994; Stone 2001; Stone, Hallé and Lange 2000). Stone (2001) showed that gold grains in surficial materials of the northern Superior Province tend to be small, silt-sized flakes whose longest dimension is less than 100 microns. These small particles are washed out of coarse beach material by the action of waves with the result that samples of beach sand contain very few small particles including gold grains. Beach sand represents a poor sampling medium for gold studies and it can be concluded that the gold grain results for beach sand samples of Table 5 provide little meaningful guidance for gold exploration.

Till contains a full range of particle sizes and the number of gold grains in till has not been depleted or enriched by the action of water. Consequently, till represents a preferred medium for assessing gold potential of an area. Stone (2001) found an average of 2 gold grains/sample in 43 till samples from a regional survey of the Stull Lake area, approximately 250 km northwest of the present area. A detailed sampling survey in an area of known gold mineralization (the Sachigo River Mine located 220 km northwest of the present area) yielded an average of 8 gold grains/sample in 45 samples. In comparison, the seven till samples from the area of the Anderson Showing contain an average of less than 1 grain per sample.

It can be concluded that the average number of gold grains in till samples from the Anderson Showing is comparable to the average number of gold grains found in the regional survey at Stull Lake. The till samples from the Anderson Showing and the Stull Lake regional survey yielded fewer grains on average than till samples from the mineralized area of the Sachigo River Mine (<1 and 2 grains versus 8 grains, respectively). Accordingly, till at the Anderson Showing appears to contain fairly normal or background levels of gold. It is important to note that the samples were collected from a small area (>500

m long) and provide an assessment of gold potential locally. Further regional till sampling is required to evaluate gold potential broadly in the Kasabonika area.

METAMORPHOSED OR MAGMATIC MASSIVE SULPHIDE INDICATOR MINERALS (MMSIMS®)

MMSIMs® are dense minerals characteristically associated with base metal mineralization. Averill (2001) discussed suites of heavy minerals associated with three types of base metal deposits including: 1) volcanosedimentary massive sulphide mineralization; 2) skarn and griesen deposits; and 3) magmatic nickel-copper sulphide mineralization. The MMSIMs® (*see* Table 6) tend to be coarse grained and visually distinctive in heavy mineral concentrates of surficial materials and can be used as indicators of economic mineralization. Stone (1994, 2001) noted that many minerals characteristic of base metal deposits also occur in non-mineralized rocks such as high-grade metamorphic rocks and barren mafic-ultramafic intrusions. For example, minerals including sillimanite, kyanite, corundum, orthopyroxene, Magnesium-spinel, sapphirine and staurolite are indicators of volcanosedimentary mineralization but also occur in non-mineralized rocks affected by amphibolite to granulite-grade metamorphism (Table 10). Similarly, although olivine, low-Chrome diopside and chromite are associated with Nickel-Copper mineralization, these minerals also occur in non-mineralized mafic to ultramafic rocks. Further, many MMSIMs® are rare minerals whose distribution is not well known in non-mineralized environments and future work may show that many mineral species in addition to those listed above are developed outside of base metal deposits. Hence, MMSIM® anomalies need to be interpreted with caution because they can originate from mineralized as well as non-mineralized sources.

MMSIMs® of the Kasabonika area include a range of sulphide minerals and Mg/Mn/Al/Cr oxide and silicate minerals (*see* Table 6). The MMSIMs® occur widely in beach sands and till and are particularly abundant in sample 01DST14, which has a very large heavy mineral concentrate (Table 4). MMSIMs® of the Kasabonika area are shown in column 8 of Table 10 in comparison with suites of minerals associated with various types of base metal deposits as well as high-grade metamorphic domains and non-mineralized mafic and ultramafic rocks. Surficial materials of the Kasabonika area contain sillimanite, kyanite, corundum, orthopyroxene, Magnesium-spinel and staurolite that are representative of either high-grade metamorphic domains or volcanosedimentary base metal occurrences. Other minerals including Mangano-epidote, spessartine, gahnite, rutile and chalcopyrite are representative of volcanosedimentary mineralization although some minerals such as gahnite (discussed below) and chalcopyrite can originate in diverse types of mineralized and non-mineralized environments. Finally, low-Chrome diopside and chromite were identified and yield an indication of either Nickel-Copper type mineralization or barren mafic to ultramafic rocks. The mineral concentrates do not contain evidence of skarn or griesen mineralization.

Mineral chemistry provides further insight on the origin of mineral grains and several minerals including gahnite, pyroxene and chromite were analysed (Table 9). Spry and Scott (1986), Morris et al. (1997) and Dunlop (2000) studied the compositional variations in zincian spinel (gahnite) associated with various rock types. These authors produced a ternary diagram (*see* Figure 4) that is useful for discrimination of the source of gahnite. Four gahnite grains from the Kasabonika area (*see* Table 9) plot within the overlap field between aluminous metasedimentary rocks, pegmatites and metamorphosed massive sulphide mineralization in Figure 4. Other Magnesium-spinels of Table 9 plot near the MgO-apex of Figure 4 and are not useful as discriminators of mineralization types.

Table 10. Indicator minerals associated with base metal mineralization (after Averill 2001), regional metamorphic terranes and non-mineralized mafic/ultramafic rocks. Shaded areas indicate mineral species presence.

1	2	3	4	5	6	7	8
Indicator Mineral	MVMS	Ni-Cu	Skarn	Greisen	Amphibolite to granulite metamorphism	Non mineralized mafic and ultramafic rocks	Minerals in the Kasabonika area (Table 6)
sillimanite							
kyanite							
corundum							
orthopyroxene							
Mg-spinel							
sapphirine							
staurolite							
anthophyllite							
tourmaline							
dumortierite							
Mn-epidote							
spessartine							
gahnite							
franklinite							
willemite							
Cr-rutile							
barite							
chalcopyrite							
cinnabar							
loellingite							
native gold							
hercynite							
olivine							
low-Cr diopside							
chromite							
uvarovite							
rammelsbergite							
sperrylite							
PGE alloys							
forsterite							
knebelite							
vesuvianite							
johannsenite							
grossular							
scheelite							
topaz							
fluorite							
cassiterite							
wolframite							

MVMS-metavolcanosedimentary

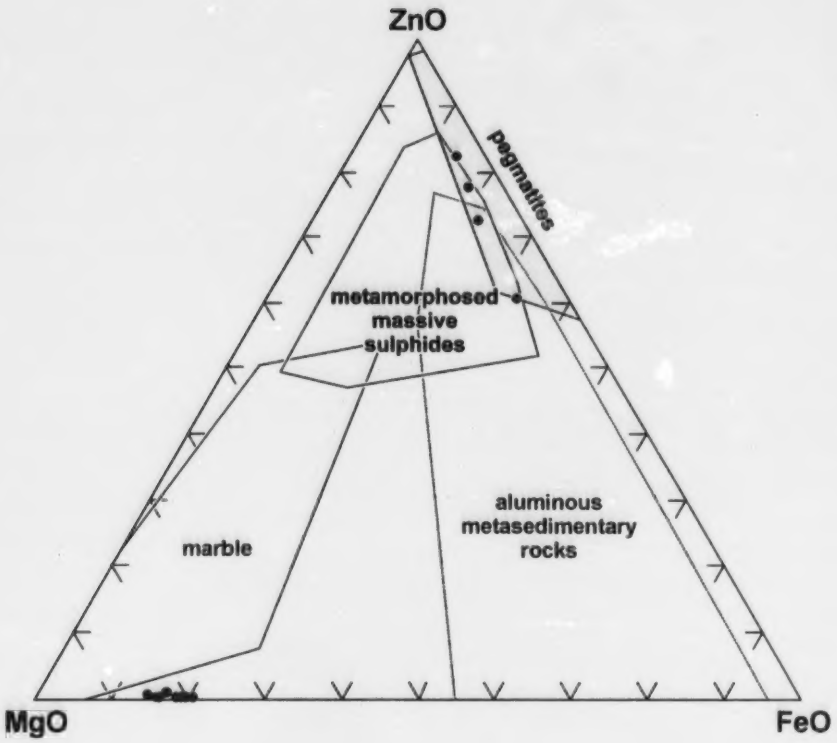

Figure 4. Compositional fields of zincian spinels from marbles (1), aluminous metasediments (2), pegmatites (3), and metamorphosed massive sulphides (4) from Dunlop (2000) with superimposed data from the Kasabonika area.

Pyroxene analyses of Table 9 are plotted on the ternary diagram of Morimoto (1989) in Figure 5a. Two groups of pyroxene grains including orthopyroxene of mainly enstatite composition and clinopyroxene of augite to diopside composition are identified. From Table 10 it is apparent that orthopyroxene grains could have originated from a wide variety of sources including volcanosedimentary sulphide mineralization, Ni-Cu mineralizatiuon, metamorphic domains and non-mineralized mafic to ultramafic rocks. There is no known mechanism for discrimination between these sources on the basis of the composition of orthopyroxene.

Morris et al. (2000) and Morris et al. (in press) assembled an extensive database of clinopyroxene compositions from known sources and provided a mechanism for discrimination of clinopyroxene sources on the basis of Cr/Al/Na systematics of the grains. Where plotted on the ternary discrimination diagram of Morris et al. (in press), the Kasabonika clinopyroxene grains are Chrome-depleted and Aluminum-rich scattering in the lower left part of the diagram (Figure 5b). Some of the more Sodium-rich grains plot within the field of kimberlitic clinopyroxenes and are discussed later. The Aluminum-rich grains plotting to the left of the kimberlitic field are representative of non-kimberlitic mantle sources (harzburgite, lherzolite, peridotite and wherlite) and crustal sources (carbonatite, gabbro, komatiite, lamprophyre and syenite) in the database of Morris et al. (in press).

Chromite grains are abundant in sample 01DST14 and show considerable variation in shape and rounding associated with wear (Figure 6). Shape characteristics of chromite grains are discussed later with respect to kimberlite indicators. Compositions of chromite have been widely used as a petrogenetic indicator (see summary of Roeder 1994) although recent work by Barnes (2000) and Power et al. (2000) indicates that chromite compositions can be metamorphically altered and petrogenetic discrimination models based on chromite need to be interpreted with caution.

Kasabonika chromite (Figures 7a, 7b) has fairly high concentrations of Cr/(Cr+Al) [0.4 to 0.8] and low concentrations of $Fe^{3+}/(Fe^{3+}+Cr+Al)$ [<0.2] at variable levels of $Fe^{2+}/(Fe^{2+}+Mg)$ [0.3 to 0.8]. Chromite with low levels of $Fe^{2+}/(Fe^{2+}+Mg)$ typically plots within the field of chromite from Ontario kimberlites (data of Sage 1996, 2000a, b) whereas Iron-rich grains show compositional similarities with chromite from mafic to ultramafic plutonic rocks (data of Roeder 1994).

In summary, the MMSIM® data provides evidence for possible volcanosedimentary and Nickel-Copper base metal mineralization in the area of Kasabonika although the indicator minerals could have originated from non-mineralized metamorphic rocks or mafic to ultramafic intrusive rocks. The compositional data of gahnite is consistent with this mineral having originated in metamorphosed massive sulfide mineralization although an association with pegmatites and metamorphosed aluminous sedimentary rocks is perhaps stronger. Metasedimentary rocks and associated pegmatites occur widely in the area (*see* Figure 2) and are noted in pebble fractions (*see* Table 3). The compositions of some clinopyroxene grains (Aluminum-rich varieties) and some chromite grains (Iron-rich varieties) provide an indication of mafic to ultramafic intrusive rocks in the Kasabonika area. The mafic to ultramafic intrusive rocks may or may not be mineralized.

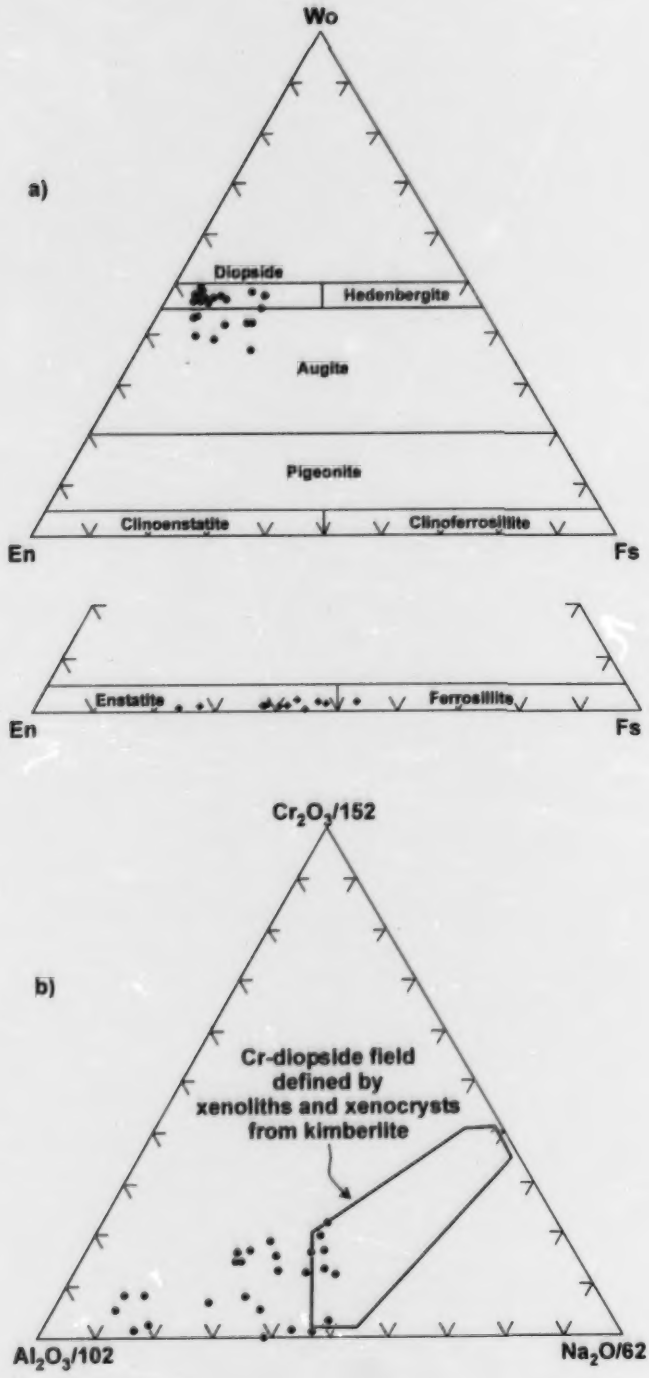

Figure 5. (a) Classification of Kasabonika pyroxene grains on the wollastonite (WO)-enstatite (EN)-ferrosilicate (FS) diagram of Morimoto (1989). (b) Compositions of Kasabonika clinopyroxene grains on the Cr/Al/Na diagram of Morris et al. (in press).

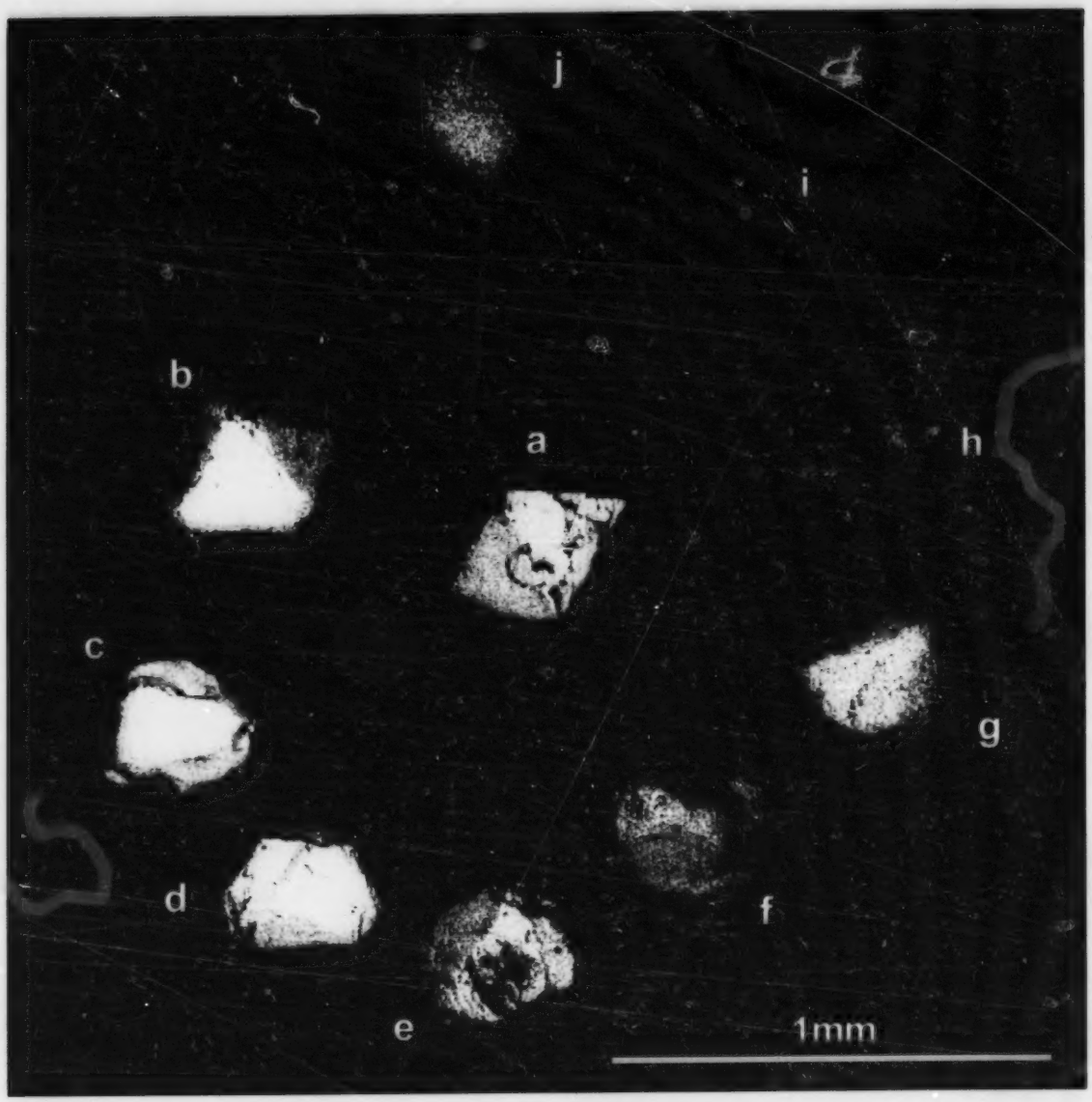

Figure 6. Scanning electron microscope image of selected chromite grains from sample 01DST14. The grains are arranged in a spiral from angular (a and b) through subangular (c, d and e) to sub-rounded (f, g and h) to rounded (i and j).

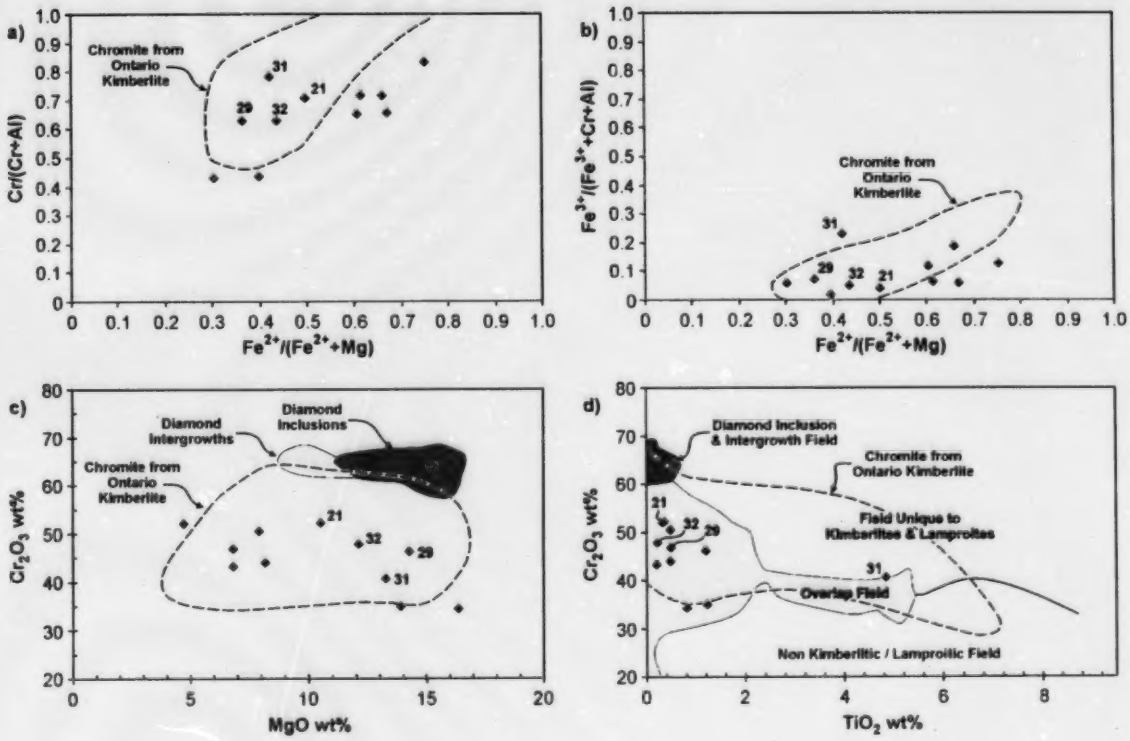

Figure 7. Compositions of chromite grains from the Kasabonika area. (a) Cr/Cr+Al)- $Fe^{2+}/(Fe^{2+}+Mg)$ relations; (b) $Fe^{3+}/(Fe^{3+}+Cr+Al)$-$Fe^{2+}/(Fe^{2+}+Mg)$ relations: (c) Cr_2O_3-MgO relations; and (d) Cr_2O_3-TiO_2 relations. Fields of chromite from Ontario kimberlite are from data of Sage (1996, 2000a, b).

KIMBERLITE INDICATOR MINERALS

Kimberlite indicators are a suite of dense minerals including pyrope garnet, eclogitic garnet, chrome diopside, picro-ilmenite, chromite and forsteritic olivine that typically occur in kimberlite. Kimberlite exposed at surface of the earth can be eroded by ice, water and wind with the result that indicator minerals are dispersed from the kimberlite into overlying surficial materials. Anomalous concentrations of kimberlite indicators can occur in surficial materials proximal to the kimberlitic source and hence, provide an exploration guide to kimberlite. Kimberlite indicators are fairly resistant to mechanical or chemical wear and are identified on the basis of their distinct colour and appearance in heavy mineral concentrates of surficial material.

Chrome diopside, chromite, ilmenite and pyrope garnet were identified and picked from the Kasabonika samples (*see* Table 7). These minerals were analyzed by microprobe (*see* Table 9) and are discussed separately below with regard to a range of chemical discrimination techniques. In some instances, the composition of a mineral grain can be used to assess the likelihood that the mineral originated from kimberlite.

Chrome Diopside

Among the analyzed clinopyroxenes of Table 9, 8 grains plot within or very near the kimberlitic field of Morris et al. (in press) and are interpreted as kimberlite indicators (Figure 5b). The clinopyroxene grains of kimberlitic origin are distinguished from clinopyroxene grains derived from other sources on the basis of elevated Na_2O. Kimberlitic clinopyroxene grains were obtained from samples 01DST10, 13 and 14.

Chromite

Sample 01DST14 contains at least 72 chromite grains that were identified at the picking stage (*see* Table 6). Eleven chromite grains were picked from the heavy mineral concentrate for analysis (*see* Table 9) and the compositions of these grains are shown in Figures 7a to d together with the compositional fields of chromite from Ontario kimberlite (data of Sage 1996, 2000a, b). Four chromite grains represented by analyses 21, 29, 31 and 32 of sample 01DST14 (*see* Table 9) plot within the fields of chromite from Ontario kimberlite on all of the discrimination diagrams (Figure 7a to d). Grain 31 is somewhat ambiguous in that it is enriched in $Fe^{3+}/(Fe^{3+}+Cr+Al)$ and plots outside the field of kimberlitic chromite (*see* Figure 7b) but is also enriched in TiO_2. Grain 31 is the only chromite grain plotting within the field unique to kimberlite and lamproite on the discrimination diagram of Fipke et al. (1995; *see* Figure 7d).

Chromite grains in sample 01DST14 are highly variable in shape ranging from angular prisms such as grains a and b of Figure 6 through subangular and subrounded to highly rounded grains such as grain i and j in Figure 6. Wear and rounding of chromite grains are discussed extensively by Stone (2001) and can occur at several stages including within kimberlite, from prolonged wear and weathering in an aqueous environment (beach), glacial transportation, saltation and by the vigorous movement of water (stream). Although some chromite grains of sample 01DST14 have large conchoidal fractures attributable to sub-glacial crushing, the highly rounded grains show extensively pitted and chipped surfaces. These surface characteristics are consistent with wear by impacting and rolling of grains such as occurs in active stream and beach environments.

Among the four chromite grains with compositional characteristics representative of a kimberlitic source, three grains are subangular (grains c, d and e of Figure 6) and one grain is subrounded (grain g of Figure 6). In some instances, mixed populations of angular and rounded grains can allude to multiple sources for the grains with the distance to the source correlated with the degree of grain wear. Angular grains showing little evidence of wear have possibly moved only a short distance from their place of origin whereas rounded grains with extensive wear might have been transported a great distance. In addition to showing a complete spectrum of angular to rounded chromite grains, sample 01DST14 has a very large heavy mineral concentrate in comparison with other samples (*see* Table 4). Progressive rounding of grains and concentration of hard, dense minerals such as chromite occurs in beach environments as softer and more brittle minerals (e.g. feldspar) are worn away (Komar and Wang 1984). Hence, the rounded chromite grains in sample 01DST14 probably reflect prolonged wear due to grain to grain impacts that occur as grains roll up and down a beach with the advance and retreat of waves. It can be concluded that the degree of rounding of chromite grains in sample 01DST14 cannot be reliably correlated with the distance that the grains have moved from their bedrock source.

Ilmenite

One grain of picro-ilmenite was identified at the picking stage in sample 01DST14. For comparative purposes, ten ilmenite grains including the single picro-ilmenite grain were selected for analysis (*see* Table 9). Where plotted on the hematite-ilmenite-geikilite ternary diagram (Figure 8), the picro-ilmenite grain falls within the field of kimberlitic ilmenites (Haggerty and Tompkins 1983). Other ilmenite grains plot near the ilmenite apex of the ternary diagram and are compositionally representative of crustal ilmenite. The single picro-ilmenite from sample 01DST14 is interpreted as a kimberlite indicator.

Garnet

Five pyrope garnet grains were identified at the picking stage (*see* Table 7) and were subsequently analyzed by microprobe (*see* Table 9). Following the discrimination procedure of Schultze (1997), the pyrope grains have in excess of 0.5 weight percent Cr_2O_3 and are interpreted to be of peridotitic as opposed to eclogitic or crustal origin. In terms of Cr-Ca systematics (Figure 9), the garnet grains have 4.5 to 6 weight percent CaO and plot within the "G9" field representative of garnets derived from a lherzolitic source (Dawson and Stephens 1975).

Summary

A suite of samples including bedrock, mineralized bedrock, beach pebbles, beach sand and till were collected in the Kasabonika area of northern Ontario. Chemical analysis of a sample of bedrock comprising amphibole gneiss at the Anderson showing (25 km northeast of Kasabonika) suggests that this rock represents a metamorphosed basalt that erupted in a volcanic arc. The metabasalt at the Anderson showing is compositionally similar to basalts of the Oxford-Stull terrane in the area of the Manitoba-Ontario provincial border. Mafic intrusive rocks on the shores of Kasabonika Lake are locally mineralized with disseminated sulphide minerals. Assays of two sulphide-mineral-bearing samples indicate sub-economic concentrations of base metals and platinum group elements.

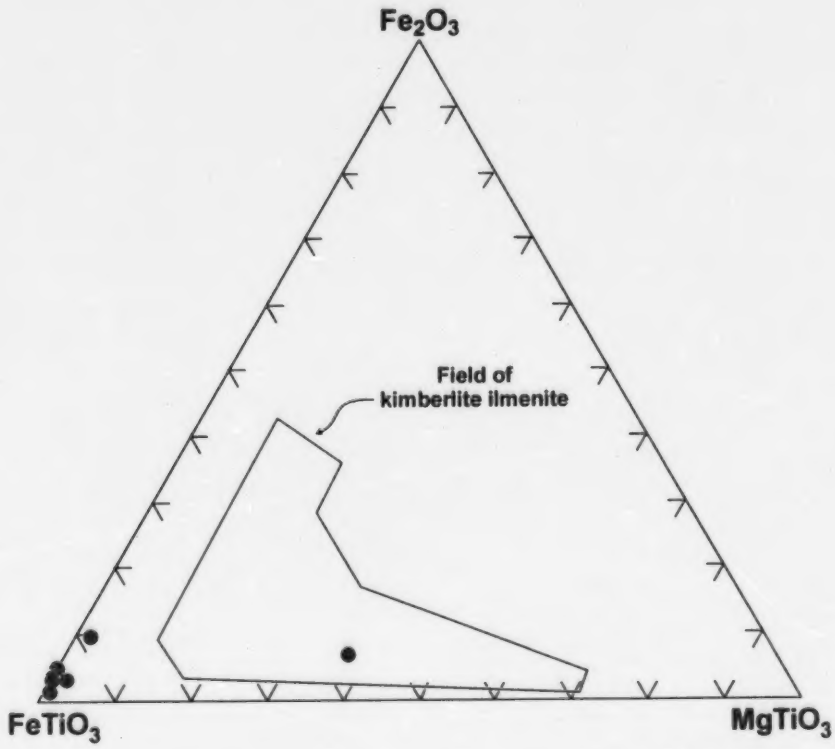

Figure 8. Ilmenite compositions from the Kasabonika area shown in terms of ilmenite-hematite-geikilite end-members. Field of kimberlitic ilmenite is from Haggerty and Tompkins (1983).

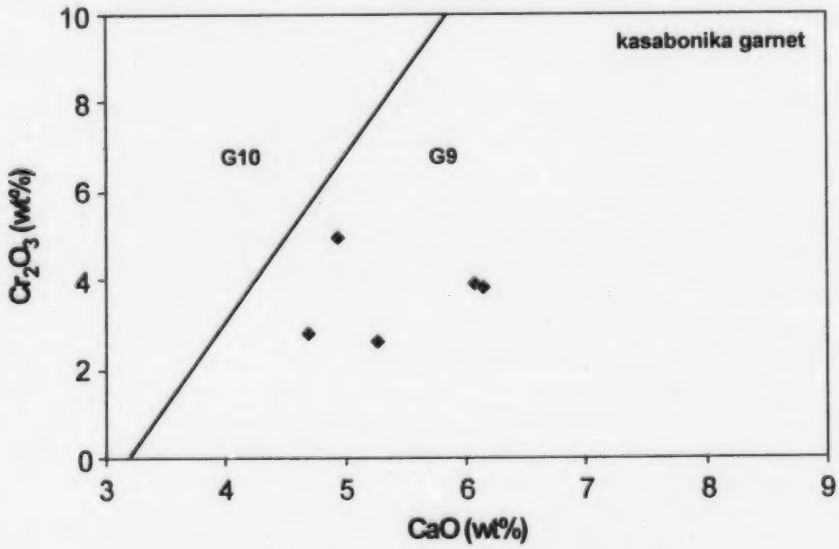

Figure 9. Cr_2O_3-CaO systematics of Kasabonika pyrope garnet.

Pebbles on beaches of Kasabonika Lake are composed of mainly mafic volcanic, wacke and assorted felsic plutonic clasts representative of Archean bedrock in the area. Up to 12% of the pebble fractions are sandstone, limestone and chert fragments. These fragments were likely transported 60 km southwest from Paleozoic strata of the Hudson Bay lowlands.

Till in the area of the Anderson showing contains background levels of gold. No gold grains were identified in beach sands of Kasabonika Lake probably because most gold grains are silt-sized particles and have been washed out of the coarser sand. Hence, the data for beach material provides little exploration guidance for gold at Kasabonika Lake. Till sampling surveys may be useful exploration tools for the definition of gold targets in the area.

Samples of beach sand from the Kasabonika area contain a suite of metamorphosed or magmatic massive sulphide indicator minerals including chalcopyrite, pyrite, spinel, diopside, rutile, kyanite, sillimanite, staurolite, spessartine, orthopyroxene and chromite. Although these minerals are associated with metamorphosed volcanosedimentary base metal deposits and Nickel-Copper deposits, subsets of the minerals also occur in non-mineralized high-grade metamorphic rocks and mafic to ultramafic intrusions. Gahnite (spinel) grains in Kasabonika sand are compositionally representative of gahnite in pegmatite and allude to occurrence of pegmatite with possible associated rare metal mineralization in the area. Some diopside and chromite grains appear, on the basis of their composition, to have originated from mafic to ultramafic intrusions although it is unknown whether or not the intrusions are mineralized.

A combination of mineral picking and microprobe analyses has identified 17 kimberlite indicator grains in 9 samples of beach sand from the Kasabonika area. The majority of kimberlite indicator grains occur in samples 01DST10 and 01DST14 (Figure 10). These samples, in particular 01DST14 have large non-magnetic heavy mineral concentrates (*see* Table 4) compared to other samples. The large heavy mineral concentrates combined with a high degree of rounding of at least some grains suggest that the dense minerals have been concentrated in these samples by placer effects[1]. Hence, the anomalies in 01DST10 and 01DST14 do not necessarily indicate that the samples are close to a kimberlitic source but rather imply that the indicator grains have been scavenged from a larger volume of surficial material.

Comparable ratios of approximately 2:1 kimberlite indicator grains per sample are found in the Kasabonika area and in the Stull Lake area of the western Sachigo Subprovince (Stone 2001). Although beach sand from both areas has been subject to placer concentration of heavy minerals, Stone (2001) interpreted the western Sachigo area as having anomalous numbers of kimberlite indicators in comparison with other parts of northwestern Ontario. Hence, the Kasabonika area together with other parts of the far-northern Superior Province appear to be broadly favourable for kimberlite exploration although more detailed sampling surveys are required to identify exploration targets.

[1] Placer effects are the mechanical processes that cause dense minerals to be concentrated in a beach or alluvial placer. Broadly, these include: 1) the wearing down and removal of soft or brittle minerals leaving a residuum of resistant and commonly dense minerals and, 2) a complex interplay between the velocity and flow mechanisms of water with the size, shape and density of particles that typically causes larger, less dense minerals to be winnowed away leaving a lag of finer, denser minerals in certain areas of a beach or stream bed.

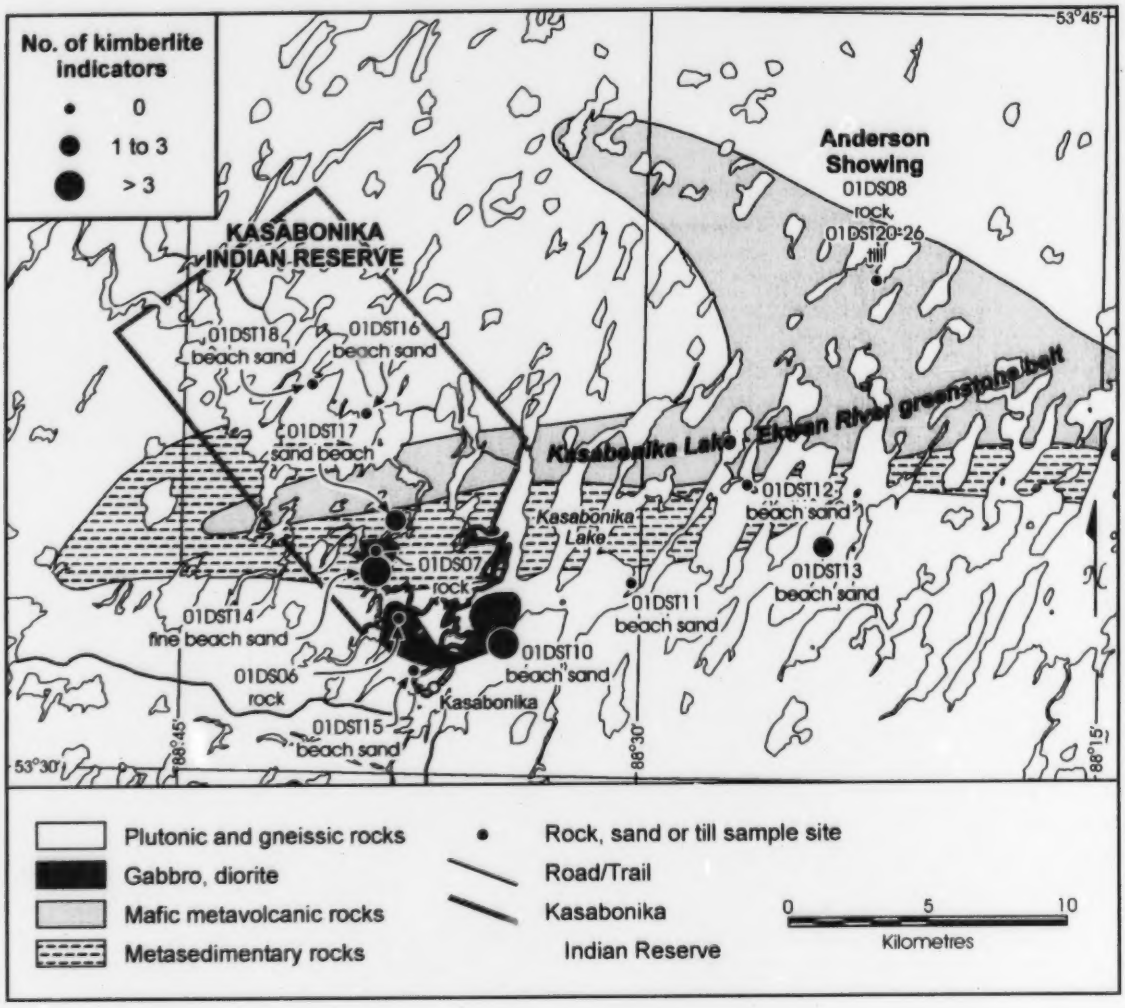

Figure 10. Distribution of kimberlite indicators, Kasabonika Lake area.

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Metric Conversion Table

Conversion from SI to Imperial			Conversion from Imperial to SI		
SI Unit	*Multiplied by*	*Gives*	*Imperial Unit*	*Multiplied by*	*Gives*
		LENGTH			
1 mm	0.039 37	inches	1 inch	**25.4**	mm
1 cm	0.393 70	inches	1 inch	**2.54**	cm
1 m	3.280 84	feet	1 foot	**0.304 8**	m
1 m	0.049 709	chains	1 chain	20.116 8	m
1 km	0.621 371	miles (statute)	1 mile (statute)	**1.609 344**	km
		AREA			
1 cm^2	0.155 0	square inches	1 square inch	**6.451 6**	cm^2
1 m^2	10.763 9	square feet	1 square foot	**0.092 903 04**	m^2
1 km^2	0.386 10	square miles	1 square mile	2.589 988	km^2
1 ha	2.471 054	acres	1 acre	0.404 685 6	ha
		VOLUME			
1 cm^3	0.061 023	cubic inches	1 cubic inch	**16.387 064**	cm^3
1 m^3	35.314 7	cubic feet	1 cubic foot	0.028 316 85	m^3
1 m^3	1.307 951	cubic yards	1 cubic yard	0.764 554 86	m^3
		CAPACITY			
1 L	1.759 755	pints	1 pint	0.568 261	L
1 L	0.879 877	quarts	1 quart	1.136 522	L
1 L	0.219 969	gallons	1 gallon	**4.546 090**	L
		MASS			
1 g	0.035 273 962	ounces (avdp)	1 ounce (avdp)	28.349 523	g
1 g	0.032 150 747	ounces (troy)	1 ounce (troy)	**31.103 476 8**	g
1 kg	2.204 622 6	pounds (avdp)	1 pound (avdp)	**0.453 592 37**	kg
1 kg	0.001 102 3	tons (short)	1 ton (short)	**907.184 74**	kg
1 t	1.102 311 3	tons (short)	1 ton (short)	**0.907 184 74**	t
1 kg	0.000 984 21	tons (long)	1 ton (long)	**1016.046 908 8**	kg
1 t	0.984 206 5	tons (long)	1 ton (long)	**1.016 046 90**	t
		CONCENTRATION			
1 g/t	0.029 166 6	ounce (troy)/ ton (short)	1 ounce (troy)/ ton (short)	34.285 714 2	g/t
1 g/t	0.583 333 33	pennyweights/ ton (short)	1 pennyweight/ ton (short)	1.714 285 7	g/t

OTHER USEFUL CONVERSION FACTORS

	Multiplied by	
1 ounce (troy) per ton (short)	31.103 477	grams per ton (short)
1 gram per ton (short)	0.032 151	ounces (troy) per ton (short)
1 ounce (troy) per ton (short)	20.0	pennyweights per ton (short)
1 pennyweight per ton (short)	0.05	ounces (troy) per ton (short)

Note: Conversion factors which are in bold type are exact. The conversion factors have been taken from or have been derived from factors given in the Metric Practice Guide for the Canadian Mining and Metallurgical Industries, published by the Mining Association of Canada in co-operation with the Coal Association of Canada.